FOREST PRODUCTS RESEARCH 1949

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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT OF THE FOREST PRODUCTS RESEARCH BOARD

WITH THE REPORT OF
THE DIRECTOR OF FOREST PRODUCTS
RESEARCH

FOR THE YEAR
1949

LONDON: HIS MAJESTY'S STATIONERY OFFICE
1951

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REPORT OF THE FOREST PRODUCTS RESEARCH BOARD FOR THE YEAR 1949

To the Lords of the Committee of the Privy Council for Scientific and Industrial Research

MAY IT PLEASE YOUR LORDSHIPS,

WE, the Forest Products Research Board, beg leave to submit our report for the year ending 31st December, 1949.

We wish to record a very full and successful year in the work of the Laboratory. The time of much of the staff still continues to be occupied to a great extent by advisory work and short-term investigations for industry and for Government. This increasing use of the services of the Laboratory brings its own satisfaction because ultimately the success of the Laboratory must be measured by the extent to which the results of its work are used by industry and the general public. It is in this sense, particularly, that the year has been full and successful. But the demands which this type of work makes upon the staff necessarily diminish by an equivalent amount the time that can be given to work of a more fundamentally scientific character. We are glad, nevertheless, to be able to report that it has been possible to make a small, though we believe inadequate, increase in such work. These more fundamental studies are essential for enabling the Laboratory to continue to provide the new knowledge on which technological advance depends, and we look forward to a considerable extension of them.

The good relations of the Laboratory with industry continue to extend and are improved by contacts made with visitors both old and new and also by fresh contacts established by officers on tour. The informal industrial panels remain a most valuable link with the associations they represent, and we would particularly wish to acknowledge gratefully the services of members from both the manufacturing and the consuming sides of industry who give their unstinted time and advice in discussions upon the technical research programmes.

We record with satisfaction the visits to the Colonies and to foreign countries made by senior members of the Laboratory's staff. Four tours have been of special interest and deserve mention. An extensive tour of the timber-seasoning and bending industries of the United States and Canada made by the head of the Seasoning Section has yielded valuable first-hand information on practice which will benefit both the Laboratory and the seasoning industry of this country. The success of this seasoning tour, just completed, was to a great extent due to the unsparing effort made by the members of the Economic Co-operation Administration both before and during the visit. We are grateful to the Economic Co-operation Administration for their sponsoring not only of this tour, but also of a projected one to the American wood-preserving industry to be made in the coming spring.

The second tour, which has been of particular interest, is one made to the Northern European countries to gain information for the Laboratory's researches upon the effect of pruning on the quality of the timber yielded by the trees. The third visit was to the plywood industries of the Scandinavian countries to learn about the manufacture of plywood from logs of small diameter, which is a matter of importance here in the utilization of certain Colonial timbers. Finally we would mention the visit paid to Northern Rhodesia to devise a technique for the sawing of 'Rhodesian teak' killed by fire. This had presented special difficulties to the technicians on the spot, and the solution of the problem gave valuable technical experience, as well as offering useful economic help to Rhodesia in making possible the utilization of this material.

The technical details of the various branches of the Laboratory's day-to-day activity are given in the Director's report. There are, however, some aspects of the year's work which are of special interest either scientifically or for their industrial value. Some brief comments on them may be of interest.

COLONIAL TIMBERS

The project on the testing of Colonial timbers still enjoys highest priority and engages much of the attention of the specialist sections. The practical task of obtaining data on these timbers is supplemented and reinforced by propaganda at both the producing and the consuming ends. Training of the utilization officers of the Colonial forest services has continued, and a new short course for members of Colonial Public Works Departments on leave has been started. In this country the demand for information on the newly available species remains unabated and daily justifies the time spent on the investigations.

The chemical analysis of selected tropical timbers continues, and some very interesting substances have been obtained. The pilot plant for the investigations on the possibility of utilizing tropical timbers for hardboard manufacture is almost complete, and the testing of the individual machines is in hand.

DRY ROT

Public realization of the importance of dry rot has been stimulated by the exhibitions and lectures which have been given during the year, and the number of enquiries about diagnosis and treatment has shown a great increase.

COOLING TOWERS

The well known deterioration of the timber slats in water-cooling towers of power stations and other industrial plants has hitherto been regarded as being caused solely by the action of the heated water, and a study of the fungal flora has shown that none of the recognized destroyers of wood is present. One which destroys cellulose has, however, been isolated. Fungi may, therefore, play a part as secondary agents in increasing the rate of deterioration—a very interesting discovery to both the mycologist and the industrial user.

DECAY IN SHIPS AND BOATS

The number of enquiries confirms the increasing interest in decay in boats. It has been possible to carry out a survey of wooden craft laid up since the war, and it has been found that the principal cause of decay is through leakages of fresh water within the ship, e.g. from plumbing defects or from water from wash basins, etc. A survey of light naval craft, in collaboration with the naval

authorities, to obtain information on the durability of plywood adhesives, has led to a large-scale experiment in which some 5,000 plywood constructional members are being exposed in various positions in service craft and are being periodically inspected to test the durability of the glues.

ASSESSMENT OF THE YIELD OF PLYWOOD

The Laboratory's tests on the production of plywood from new timber should give information, not only on the suitability of the timber for plywood manufacture, but also of the yield. Such information should clearly be made available in a form likely to be most directly useful to individual firms in assessing production possibilities including costs. With the assistance of a panel drawn from the industry a method of presenting this information most advantageously from this standpoint has now been evolved and is being tried out.

SAWING STUDIES

For some time the stroboscopic method has been successfully used at the Laboratory for the studies of the action of cutting edges upon timber. A technique employing either the strobotorch or high-speed photography has been evolved for observing the behaviour of the sawdust in the tooth gullets of a circular saw. One side of the saw is in contact with a toughened glass window, through which the quantity and path of the sawdust can be either continuously observed or photographed while the saw is in operation at different speeds. This method obviates the errors caused by having to stop the saw and open up the wood for inspection of the sawdust in the gullets.

E. J. SALISBURY,
Chairman

October, 1950.

REPORT OF THE DIRECTOR OF FOREST PRODUCTS RESEARCH FOR THE YEAR 1949

INTRODUCTION

The work of the Laboratory for the year 1949 has continued largely along the lines reported for the last several years—the accumulation of data on new timbers which will help to meet the present shortage of timber, the search for substitute timbers, more efficient utilization, and a still increasing volume of advisory and short-term work in all branches of the Laboratory's work.

The connexions with industry and with other Government Departments have been maintained and strengthened, and the Laboratory's specialist officers continue to serve as advisers on many technical committees and panels.

The full-scale investigations on the properties of Colonial timbers still enjoy high priority. In the Report for 1948 the relation of these investigations to the timber situation was discussed. It will suffice at this time to repeat that highest priority is being given to species available for export from the Colonies and of potential value for the wood-using industries in the United Kingdom.

The plan for economic recovery in Western Europe involves extensive substitution of tropical timbers for the traditional commercial species (both hardwood and softwood) which are in short supply, and in so far as these are also used or are capable of being used in the producing countries, as so often happens, the results of the Laboratory's timber investigations are of direct application to problems of utilization in the Colonies themselves.

In addition to investigating Colonial timbers for the United Kingdom market, the Laboratory has also undertaken certain tests of species intended mainly for the local Colonial market. Such species, while directly of interest to the Colony concerned, have been selected as being indirectly beneficial to the United Kingdom in that they may, by helping to develop local markets, influence the possibility of export of these or of more desirable species.

To broaden the liaison between the Colonies and the Laboratory a special course was arranged in May 1949 for members of Public Works Departments on leave. This proved to be a success and will be repeated. Provision has again been made for longer periods of instruction for utilization officers of the forest services.

The question of the increasing volume of advisory work, with the associated short-term investigations noted in the Programme of Research, has now become one of major importance. The Reports of previous years have indicated the greatly increasing demand made on the Laboratory for advice and short-term work. In most sections this service now absorbs an abnormally large proportion of the total available time, to the exclusion of any continuous work on longer-term projects—not only those of the 'fundamental' type, but also those of the applied type so necessary in the technological field. The accumulation of new data is in fact now largely a by-product of the *ad hoc* experimental work.

Routine enquiries about such subjects as domestic insect pests, e.g. furniture beetle, or simple occurrences of dry rot can easily be dealt with in any quantity. It is difficult to give a figure for routine replies by leaflet, as more than one leaflet may be sent in reply to one letter of enquiry, but a total of 48,300 leaflets has been distributed from the Laboratory during the year, and 13,300 at official exhibitions.

The number of replies requiring the attention and time of senior officers—i.e. by report, letter, telephone or to visitors, but excluding routine reply by standard leaflet—is, however, becoming steadily greater and is now in the neighbourhood of 13,000 annually. As an indication of the increase in technical correspondence, the number of enquiries answered by letter or report was 5,621, as against 4,200 for 1948 and 3,700 for 1947. In one or two branches of the work, e.g. in composite wood, wood preservation and timber mechanics, the figures show, for the present at any rate, a relatively slow rise, but in others, particularly those in which the Laboratory's work is becoming more widely known, e.g. in utilization, woodworking, seasoning, wood bending and chemistry, there is a more rapid increase. Or where public consciousness is being awakened, as for instance with respect to rot in buildings and in boats, or insect attack in houses, churches and public buildings, the curve of enquiries is rising very steeply, with no sign of any falling off. The overall total of enquiries for the Laboratory therefore shows a substantial yearly increase. This places the Laboratory in a progressively difficult dilemma. The flow of industrial enquiries is a healthy sign, as well as a most encouraging indication of the increasing confidence of the trade. It enables the specialist sections to keep abreast of and even to anticipate technical problems. Practical enquiries are the life-blood of a technological establishment and should not be restricted or, even if it were possible, diverted. On the other hand, without a minimum of research work the Laboratory would ultimately become simply a purveyor of information, however efficient. Provision has been made both for the apparatus and the working space for present and future trends of research, but the problem is essentially one of staffing. Apart from the Laboratory, there is no training centre for timber technologists, and it is therefore forced to recruit at basic levels. Even so, recruitment is difficult for several reasons, chief of which are a shortage of available people and the geographical position of the Laboratory itself, which is too far from a University to attract or retain junior staff who wish to carry on evening study for a degree; there is also the limitation imposed by the permitted complement. No solution of the difficulty has yet been found, but it is clearly the crucial factor.

GENERAL

BUILDINGS AND EQUIPMENT

The conversion of the first of two huts as part of a permanent chemical laboratory has been completed, and most of the pilot-scale apparatus for the experimental manufacture of hardboards from tropical timbers, which is being carried out for the Colonial Products Research Council, has been delivered and is in course of erection.

The detailed plans for the new Woodworking, Wood Bending and Timber Structures laboratories and for the extension to the Woodworking Machine Shop have been approved. Building is expected to begin early in 1950.

STAFF

The general position in regard to staff complement remains relatively unchanged. There has been a slight increase in the number of junior staff recruited, and two specialist senior experimental officers have been appointed during the year, one with long experience in tropical forestry for work in utilization, the other with wide experience in industry for the section of woodworking. The net gain for the year is 4 persons.

During the year the Laboratory has lost two very valued senior officers who had been in its service since its early days. In May Mr. H. A. Cox, head of the Section of External Relations, retired, and in September, Dr. W. W. Barkas, head of Physics Section, resigned to take up an academic post.

TOURS

During the year the experience of the Laboratory has been further strengthened and brought up-to-date by surveys carried out in other countries by three of its senior officers. In the spring, a visit was paid to Germany, Sweden and Norway in connexion with the research on the pruning of conifers and its effect on the knottiness of their timber, one of the collaborative projects with the Forestry Commission. The findings of the visit are referred to later in this Report. During the summer the head of the Section of Composite Wood toured the plywood industries in Finland, Sweden, Denmark and Holland. In addition to the general survey, a special object of the visit was to learn about the manufacture of plywood from logs of small diameter, which require special techniques which have been developed in Finland and Sweden to a high level of efficiency. As part of the general scheme for the evaluation of Colonial timbers for possible exploitation, search is being made for suitable species for plywood manufacture, and some of these will yield logs of the smaller diameters which will require these special methods of treatment.

At the end of the year, the head of the Section of Seasoning and Wood Bending made a 3 months' tour of the United States, with a short visit to Canada, to survey their seasoning and bending industries. Such a survey had not been made from the Laboratory for some 20 years, and the information gained will be of very great help not only in the research work, but also particularly in the Section's advisory work. The tour has attracted great interest in the trade and arrangements have already been made to give a series of lectures on American practice at important centres in this country. The tour was arranged by the Economic Co-operation Administration, whose kindness and good offices are gratefully acknowledged. Two other visits abroad have been made by senior officers. One, at the invitation of the Governor of Northern Rhodesia, was undertaken to investigate the conversion of the very refractory timber of 'Rhodesian teak' obtained from fire-killed trees. The successful solution of this problem was of great technological interest. The other visit was made to the Zentralinstitut für Forst- und Holzwirtschaft, Reinbek, near Hamburg, to see the work in progress and to explore the possibility of arranging for sponsored research in wood anatomy.

During 1949 the Laboratory was represented at several conferences held on the Continent. These included the 3rd World Forestry Congress of the Food and Agricultural Organization of the United Nations, and conferences in Paris (Organization for European Economic Co-operation), Geneva (Timber

Mechanics, F.A.O.), and Brussels (Chemistry, F.A.O.), which were attended by technical experts.

INDUSTRIAL PANELS

The three informal panels, the Adhesive Makers' Panel, The Radio Frequency Panel, and the Plywood Research Panel, continue to meet regularly to discuss those aspects of the research programme of interest to the relevant branches of industry. One records with pleasure the close collaboration resulting from the co-operation of the various associations and from the unstinted services given by the panel members themselves.

PUBLICATIONS AND RECORDS

Four new publications were issued through the Stationery Office during the year, namely, Bulletins No. 22 on the "Identification of Softwoods by their Microscopic Structure" and No. 23 on "Flooring Softwoods. Their Wear and Anatomical Structure"; Record No. 30 on "The Natural Durability of Timber"; and the book "The Swelling of Wood under Stress". Two new Leaflets (Nos. 44 and 45) and a supplement to Leaflet No. 42 were also issued. No. 44 "The Seasoning of Exotic Timbers—Part 1" provides much needed data on the behaviour in kiln-drying of many recently imported species, and No. 45 "The Steam Bending Properties of Various Timbers—Part 1" gives up-to-date information on all the numerous species so far tested at the Laboratory.

Permission has been granted to the Forest Research Institute, Warsaw, to publish a Polish edition of the book "Decay of Timber and its Prevention". This will be the second foreign edition of this work, the first having been issued in the United States.

Following a resolution by the Commonwealth Entomological Conference, London, 1948, a simple manual[1] dealing with the protection of buildings and building materials from termites has been prepared for the practical builder. This publication, which has been written by an officer of long tropical experience and in collaboration with the Colonial Liaison Officer of the Building Research Station, is based on the Laboratory's records over 20 years and upon reports from the Dominions and Colonies, kindly made available by the Director of the Commonwealth Institute of Entomology.

Details of the reports published during the year, including papers in the scientific and technical press, are contained in Appendix II. Twenty-six other reports dealing mostly with plywood and seasoning were also prepared for limited distribution.

INSTRUCTION

It has still proved impracticable to hold any systematic course of general instruction during the year, but it has again been possible to arrange a few special courses, including one on timber technology for the instructors of the Timber Development Association. The customary short courses were provided for undergraduate forestry students from the Universities of Aberdeen, Bangor, Cambridge and Edinburgh, and for 42 students (including 15 from the Colonial Forest Services) of the Imperial Forestry Institute, Oxford. Other special courses were arranged for the Supplies Division of the Ministry of Works and

[1] MacGregor, W. D. The Protection of Buildings and Timber against Termites. *Bull. For. Prod. Res. Lond.*, No. 24.

for senior officers of the Public Works Departments of West and East African Colonies. Three Colonial utilization officers from Tanganyika, Uganda and Ceylon, respectively, have also spent periods of from three to six months at the Laboratory. The training of utilization officers is regarded as a very important part of the educational work because of their value in maintaining liaison with the Forestry Departments and in spreading knowledge of the technological requirements for the successful utilization of tropical timbers.

Day visits by parties are still of necessity strictly confined to industrial and professional bodies, which this year have included architects, builders, civil engineers, woodworking operatives and mycologists.

Seven of the customary courses for kiln operators have been held. The number of trainees was 67. In wood bending, four trainees have received courses of instruction.

DISSEMINATION OF RESULTS

Visits

The usual large number of visits by senior officers has been made to many centres throughout the country for the purpose of maintaining industrial contact, lecturing, etc. At the invitation of the Ministry of Commerce of Northern Ireland, a lecture on the work of the Laboratory was given to the timber trade there, and a tour of visits was afterwards made to a number of firms.

Lectures

The increasing public interest in dry rot and insect pests is reflected in the number of requests for lectures and broadcast talks on these subjects, in addition to the normal technical lectures on other subjects given in various parts of the country. The Laboratory has also taken part in three of the 'Brains Trusts' arranged by the Timber Development Association at London, Cambridge, and High Wycombe.

Exhibitions and Films

Much of the exhibition work during the year has been directed to publicity in connexion with dry rot and insect pests. Exhibits were arranged at the Building Trades Exhibition, Olympia, and The Building Centre, London, and special exhibitions were staged at London, Belfast and Glasgow. The attendance at these was so great and the local interest so encouraging that arrangements have been made for a travelling exhibit to visit about 30 towns in England and Scotland in 1950-51.

An exhibit of Empire timbers and a demonstration of the work of the Laboratory was given at the Institution of Civil Engineers in June, and an appropriate selection of timbers and examples of work on seasoning, preservation, etc., formed part of the Forestry Commission's exhibit at the chief agricultural shows in England during the summer.

With present-day circumstances and limitations in mind, the Laboratory's publicity and propaganda for the more efficient utilization and protection of timber can be said to be very satisfactory. Much, however, has had to be curtailed, and the active side of taking information to industry by direct contact has been severely restricted. It must, moreover, be remembered that publicity

adds to the general advisory dilemma. The more efficient it is the greater is the number of enquiries for technical advice.

PROGRAMME OF RESEARCH

COLLECTION OF TIMBER SPECIMENS; IDENTIFICATION STUDIES

Additions to the Laboratory's reference collection of timber specimens has included small collections from British Guiana, Dominica (B.W.I.), Argentina and Siam. Many samples of commercial timbers have been received through trade channels; these help to keep the Laboratory informed of current timber imports and to increase our knowledge of the normal range of variation in commercial timbers.

Good progress has been made with the Laboratory's card key for the identification of hardwoods, based on microscopic features, which is in constant use. During the year some fifty additional species, mostly timbers of economic importance, have been incorporated in the key. The bulk of the work involved in extending and revising the lens key for the field identification of hardwoods has been completed, and it is nearly ready for publication.

GENERAL TESTS OF TIMBERS

The annual Report for 1948 showed that at the end of that year some 25 timbers from West Africa, 8 from East Africa, 4 from British Guiana and 4 from Malaya and Chile were under test or waiting or ordered for testing. Work on these timbers continued and in August 1949 test logs of *Tarrietia* (nyankom) arrived in good condition from the Gold Coast Forest Department; but in September, 1949, that Department reported that attempts to send test logs of two other species to Princes Risborough had failed: *Aningueria*, from splitting of the logs (up to 40 ft. from the butt); and *Cleistopholis*, from stain and pinhole borer attack, even although the logs of the latter species were treated with insecticide within 3 days of felling. These two instances exemplify the difficulties which may have to be overcome in the exploitation of species which, on *prima facie* assessment, are worthy of test. This temporary set-back coincided with unforeseen delays in getting timber from the Nigerian Forest Department, owing to the difficulty of identifying accurately various species of *Brachystegia* (okwen), an important element in the rain forest. The absence of these probably more important timbers allowed some species of lower priority to be tested, including *Cynometra* (muhimbi) from Uganda, a plentiful timber which is something of a problem in utilization. In the event, however, *Cynometra* has proved to be a good heavy-duty flooring timber, useful in the United Kingdom as an alternative to maple, which is scarce owing to lack of dollars, and provides an instance in which tests undertaken primarily for an overseas territory may also unexpectedly directly benefit consumers in the United Kingdom.

In December the despatch of botanically identifiable test logs of three timbers, *Sterculia oblonga*, a *Berlinia* and a *Pterygota*, was notified by the Forest Department of Nigeria. The logs have arrived in good condition.

Through the courtesy and co-operation of private importers and distributors, small amounts of green-sawn *Afrormosia* (kokrodua) from the Gold Coast were

got for seasoning, woodworking and strength tests from stocks in the United Kingdom. The timber is important as a possible alternative to teak where stability and durability are desirable, as in ships' decks.

In connexion with the testing programme, full discussions have taken place with commercial and forest service officials about the primary and secondary timbers of British Guiana. Of these, some are exportable to the United Kingdom, some may help to increase the availability of exportable species and some will be of possible importance only to the Colony itself. Of 42 species of major or possibly appreciable significance, 13 of the most important have been tested or are under test at Princes Risborough, 4 have been tested at Yale, 7 have been chosen for testing here when other commitments allow, and 18 timbers remain to be considered. All of these last 18 are comparatively scarce in the more accessible forests so far sampled.

DATA FOR UTILIZATION

There is still an unabated demand for identification and information as to properties, uses and quality of a wide range of timbers, many of which have been offered to the enquirer under unfamiliar names. Some of the timbers now being marketed have never been adequately tested, and where this is so their merits must be assessed as far as possible by the examination of hand specimens, together with such additional information as is available in the Laboratory's records. Timber importers, also, in their search for new sources of commercial timbers, enquire about the kinds of timber likely to be available for export from different parts of the world. A common type of enquiry has to do with the selection of timbers for special purposes, often involving the use of comparatively unknown species in place of old-established ones temporarily unobtainable. During the year the liaison with consumers and distributors in this country and with foresters and other suppliers at home and overseas has been maintained and extended.

EXPERIMENTAL WORK IN PLANT PHYSIOLOGY

Physiology of Heartwood Formation

One of the most interesting problems in the physiology of trees is that of the metabolic changes which occur when sapwood becomes transformed to heartwood. In addition to its purely scientific interest, the change is important because of the absence in the heartwood of the tree of those plant reserves which are present in the sapwood and which are also the food of *Lyctus* and other insect pests. The question of differences in natural durability may also be involved. In an attempt to elucidate the physiological changes accompanying the transformation of sapwood to heartwood, experiments have been started to investigate the effect of girdling on the cell contents of the sapwood of standing trees. Microscopic examination of increment borings is being made at intervals to observe the progressive changes induced by this treatment.

Starch Depletion in the Log

If the sapwood of a newly-felled log is kept under conditions in which its living cells do not die, the starch reserves and possibly other substances present become gradually depleted below the limit at which *Lyctus* will infest. Work previously in progress on the manner of this depletion has been resumed, and a laboratory experiment has been carried out to investigate the effect of tempera-

ture on its rate. The results of storing ash billets in water at temperatures ranging from 64° to 99° Fahrenheit indicate that only a moderate increase in the rate of starch depletion is obtainable over this range, since at temperatures higher than about 70°F. depletion appears to be inhibited, presumably by the accumulation of respiratory gases in the interior of the log. It is noteworthy that earlier work on thin boards and cross-sectional disks freely exposed to the air showed that the rate of depletion increased progressively with temperature up to about 99°F.

RESEARCH ON PRUNING

In March a senior officer visited Germany, Sweden and Norway to study the effects of the pruning of conifers on the reduction of knots in the wood, spending 15, 4 and 2 days in each of these countries, respectively. The chief points which emerged were the much stronger reasons for pruning Douglas fir and special quality Scots pine than for pruning spruce (except the very best) or ordinary Scots pine; the danger on the Continent, and perhaps in Britain also, of green-pruning spruce and admitting fungal decay; and the lack of clear evidence on the economics of pruning. The current work on pruning in South and East Africa, including that at the Forest Products Institute, Pretoria, may eventually provide clues to assessing the real value of pruning in Great Britain.

Meanwhile the collaborative practical work with the Forestry Commission on pruning has continued. Eleven out of 28 lots of Norway and Sitka spruce from a wide range over England, Scotland and Wales have been examined. Numerous (1,429) knots have been analysed for time to heal, radial depth of healing wood, soundness, etc. The average time to heal has been found to be about 5 years. Pruning the side branches early, whilst the main stem is still of $2\frac{3}{4}$ to $3\frac{1}{2}$-inch diameter under bark, reduces the size of the knotty core and increases the amount of knot-free outer wood in the main stem more effectually than any refinements of close or smooth cutting of the side branches in wider stems.

Some indications have been found that, as was noted on the Continent, it may be unsafe to green-prune spruce, owing to risk of canker, and that it may prove safer to wait till the branches die before cutting them.

PHYSICS

Wood-Water Relationships

The measurements of vapour pressure isothermals, using quartz springs to determine moisture content changes, have been continued on Sitka spruce. An apparatus has been constructed with which measurements can be carried out on five samples at once. This saves considerable time, as it is found necessary to wait 24 hours between readings for the establishment of equilibrium. The apparatus is first evacuated, after which water vapour is admitted in small amounts until saturation is reached. The vapour pressure is next reduced by small stages to zero, readings of weights and vapour pressures being taken after equilibrium has been reached at each stage. Relative humidity is then plotted against moisture content, and the well known hysteresis loop obtained.

In some experiments, at present in progress, the isothermals lying within this loop are being studied, that is to say, the vapour pressure is taken through part only of the complete cycle from dryness to saturation. In this way, the

effect on the isothermal of passing from adsorption to desorption conditions and *vice versa* at any relative humidity can be observed.

Experiments on the restrained swelling of spruce blocks have been completed. The results show that on applying small increments of pressure and allowing the wood to come to equilibrium at a constant relative humidity of 86 per cent, the lowering in moisture content is practically nil, owing to the relaxation of stress at this high humidity. Thus, when the clamps are released again in small stages, the original dimensions are not recovered, a result which has been observed previously by other workers.

Diffusion of Water Vapour through Wood

Experiments made some years ago indicated that there was a marked increase in the rate of diffusion of water vapour through beech as the surrounding air pressure was lowered. The method used was to cover the mouth of a 4-oz. bottle containing water with a disk of wood and to weigh the assembly after various periods of exposure to phosphorus pentoxide. In connexion with seasoning projects, these experiments have been repeated on beech and oak, and opportunity has been taken of improving the technique. According to the new results, the diffusion rate at all pressures is greater through beech than through oak, and it increases for both species with decreasing air pressure. The increase in the rate through beech is, however, considerably less than that obtained earlier. The discrepancy is probably due to the difficulty of obtaining an efficient seal between the disk of wood and the bottle top, and an improved apparatus constructed of "Perspex" has been designed and made. This apparatus gives a positive pressure, exercised by means of a screw thread turned in the "Perspex", on the surfaces at the edge of the wooden disk, and should therefore be less liable to errors owing to leakage of vapour past the edge. Using this apparatus, the rate of diffusion of water vapour in both the radial and tangential directions has been measured on beech, oak, Scots pine, spruce and krabak. The tangential flow through beech and oak was found to be appreciably greater than the radial flow, but with the other three species, the difference was not so marked.

An apparatus of new design is under construction, incorporating a special manostat which, it is hoped, will enable any desired pressure differential to be maintained across a wood specimen, and hence allow the diffusion rate of different gases through wood to be measured.

Humidity and Temperature Control

It is often desirable to know the effect of temperature on various physical properties of wood, but accurate results are difficult to obtain because it is not easy to alter the temperature of a piece of wood without altering its moisture content. There is, therefore, a need for a method of controlling humidity and temperature simultaneously to, say, 1°C. and 1 per cent relative humidity from 20°C. to 90°C. and from 10 per cent to 90 per cent relative humidity. The requirements for temperature control are relatively simple to meet, but those for humidity control are stringent, and the following methods of attaining the required control have been tried:—

(*a*) The dew-point method, in which the formation of dew on a cooled mirror surface affects the supply of light to a photoelectric cell and hence through a relay system, controls the amount of water vapour in the

heated space. This method needs elaborate equipment and, in addition, it has been found that the mirror surface gradually becomes contaminated, leading to loss of sensitivity.

(*b*) Wet and dry bulb contact thermometers. This is essentially a simple method, but the thermal inertia of the wet bulb leads to variations in humidity of about 5 per cent.

(*c*) Wet and dry bulb thermocouples. This method gives rapid response, but the wick dries up at high temperatures and causes erratic control. The associated apparatus is elaborate and fragile.

(*d*) Saturated water vapour method. This method involves passing air through water at a controlled temperature and leading the resulting saturated air into a warmer chamber, the temperature of which may be independently controlled. The relative humidity of the chamber is determined by the ratio of the saturated vapour pressures at the two temperatures.

The preliminary trials indicated that method (*d*) was the most promising, and an oven has been built which appears to be satisfactory from 20° to 90°C. and from about 30 per cent to 90 per cent relative humidity, although the oven has not yet been given an extended run at the highest temperatures and humidities. During the development of the oven it was found necessary to take special precautions to ensure that the air was completely saturated at the lower temperature; in particular, the air must be heated before passing to the saturator, and the saturator itself constructed of metal, so that heat loss, caused by evaporation of water into the air stream, is rapidly made good from the thermostat in which the saturator is immersed.

Elastic and Plastic Properties of Wood

The experiments on the creep of solid wood under shear stress and on the effect of temperature and humidity upon the rigidity modulus of wood have been continued. Some attention has been paid to methods of measuring the velocity of sound in wood, since if a satisfactory method could be developed it might be applicable to investigating the effect of stress on the elastic properties of wood. A simple mechanical arrangement in which a hammer blow excites longitudinal vibrations in a wooden beam was tried. The rate of propagation of the waves along the beam was timed by an electrical method, but it soon became apparent that this arrangement was not sensitive enough and that considerable development work would be required to increase the sensitivity. It was, therefore, decided to make some trials in an apparatus which had been developed at the Road Research Laboratory for measuring the velocity of sound in concrete, by observing the time required for a pulse of ultrasonic energy to travel through a known distance of the material. Preliminary experiments showed that the velocity in wood could be determined quite reliably and accurately, but measurements of the velocity in stress-free wood and in wood under compressive stress showed no difference between the two and the work has therefore been discontinued.

Electrical Properties of Wood

Measurements have been made of the dielectric constant and loss tangent of 10 air-dry timbers of density ranging from 0·18 to 0·60 gm/cc, between frequencies of 1 and 60 megacycles per second. In agreement with results

recently published in America the results show a close correlation between dielectric constant and density but little correlation between loss tangent and density.

Although it is usual to express the electrical properties of wood in terms of dielectric constant and loss tangent, there are actually two further modes of expression which are sometimes used for other substances: (1) in terms of the attenuation and phase constants of a plane electromagnetic wave travelling through the substance; and (2) in terms of refractive index and index of absorption for electromagnetic waves. Values expressed in any one system can be expressed in the other two by simple conversion and these conversions have been made on the results mentioned above. A recent enquiry asked for information regarding the attenuation of wireless waves in wood, and this information was supplied on the basis of these results.

The Schering bridge for use at frequencies below about 1 megacycle has been completed and tried. It has behaved reasonably well, but still remains capable of improvement in some respects. In particular, when working at frequencies above about 100 kc/s, it is important that the wiring should introduce as little capacity and inductance as possible between the various arms of the bridge. The present model was assembled from such components as were available in the Laboratory, and consideration was therefore given to the design of a bridge using special components and incorporating those features which experience with the present bridge has shown to be desirable. This new bridge has been assembled and is now being tested.

A phase-shift oscillator has been built, primarily to cover the range from 20,000 to 100,000 c/s, but by a simple change of plug-in resistance units, the range can be usefully extended down to 300 c/s.

The new apparatus for measuring dielectric constant and power factor by a resonance method has been assembled and calibrated on the Schering bridge against a standard condenser provided by the National Physical Laboratory. A final check on the apparatus has been carried out by making measurements on "Perspex" disks of various thicknesses.

In addition to assistance rendered within the Laboratory on such subjects as electrical resistance strain-gauges, general elastic theory, and the thermal and electrical properties of wood, the Section of Physics has supplied information on the last two subjects to external enquirers, who have also been given information relating, among other matters, to the attenuation of wireless waves and the detection of metal in wood, and on methods of humidity and temperature control.

SEASONING

Kilns and Kiln-seasoning

During the course of the year, the Laboratory has undertaken a considerable volume of work in connexion with the seasoning of oak and other timbers for the rebuilding of the House of Commons. Most of the oak required, much of which was of exceptional thickness, has been successfully kiln-seasoned from virtually a green condition; it may be mentioned that the period of kilning required for the seasoning of some of the loads of 4½-in. quartered planks was no less than ten months.

Ancillary tests were also carried out to check the conditions under which

joinery made from the dried oak was manufactured and stored, and additional tests were made in co-operation with the Building Research Station to determine when the new building was in a suitably dry condition to receive the woodwork.

Special gift consignments of timbers from Australia, New Zealand and other countries of the Commonwealth have been kiln-seasoned at the Laboratory, including black bean for the Speaker's chair and puriri for despatch boxes.

An investigation was carried out in co-operation with a firm of rule manufacturers to determine how best to season Maracaibo boxwood slats for the making of measuring rules, and a special high-temperature low-humidity drying schedule, particularly suitable for such small-dimensioned material was evolved by which the slats could be seasoned in about $2\frac{1}{2}$ days. Recommendations were then made as to a suitable type and design of kiln plant for the seasoning of similar material on a commercial scale.

The seasoning properties of many other exotic timbers that have been imported recently from Africa and elsewhere have been tested in the Laboratory's experimental kiln plant, and leaflets describing the behaviour of a number of these have been prepared and issued.

Alterations and Additions to Plant. The old basement kiln that was converted into a side fan unit has had considerable use, and reasonably satisfactory results have been achieved in it, at least with the side fans run so as to draw air through the load. The uniformity of air circulation was not so good when the direction of circulation was reversed and the air blown straight from the fans into the timber stack.

Two of the old model kilns that were constructed mainly of wood and were in a dilapidated condition have been dismantled and replaced by brick units (Plate 1(A)). There are several novel features incorporated in these brick models, such as aluminium-faced doors, trolley loading at ground level, etc., and they show a marked improvement on the older designs.

Radio Frequency Drying

In the report for 1948 it was stated that the successful application of radio frequency heating to the seasoning of timber would probably be limited by practical and economical considerations to the drying of dimension stock of permeable species of sufficient value to make speed of drying, rather than cost, the overriding factor. Research work has been continued during 1949, but on a reduced scale, and, among other results obtained, it has been found possible successfully to dry beech squares 6 × 6-in. in cross-section by the 'boiling' method from the green to 12 per cent moisture content in $1\frac{1}{2}$ hours with surprisingly little degrade (Plate 1(B)). Thus although neither the 'boiling' nor the 'temperature gradient' method has proved too promising for the seasoning of thinner material and refractory species, it might prove economical and practicable to season large-dimensioned material of permeable species, such as beech and sycamore, by the 'boiling' method. A visit has been made to a firm already engaged in the drying of specialized items by such means, with the object of studying their results, and of acquiring a better appreciation of the commercial possibilities of the method.

An article[1] has been published in a technical journal giving a description of

[1] PRATT, G. H., and DEAN, A. R. Radio Frequency Drying of Timber. *Wood*, 1949, 14(2), 46-50.

the apparatus used for the radio frequency drying tests at the Laboratory, and including a resumé of the general findings to date.

Performance Tests of Doors

Work has been undertaken in co-operation with the Ministry of Works to determine the behaviour of various types of doors when subjected to different atmospheric conditions on the opposite faces.

An existing building has been converted into what are essentially three long corridors in which the humidity conditions of the air are maintained at 45, 75 and 90 per cent, respectively.

Test doors are hung between the central corridor which is maintained at 45 per cent humidity, and the other corridors. When moisture equilibrium is established in the doors, measurements of distortion and other defects are recorded so that an assessment can be made of their probable behaviour in service.

Electrical Moisture Meters

Although electrical determination of moisture content has not been a subject for special study during the year, numerous enquiries have been received from makers, prospective makers and users of such instruments, and a brief review of the position might not be inappropriate here. Most instruments for moisture content estimations in wood rely upon a measurement of the electrical resistance of the material to give an indication of the moisture content. If the instrument can measure resistances from, say, 100,000 ohms to 10,000 megohms, it can, in fact, be relied upon to give a reasonable estimate of moisture content over the range of about 7 to 25 per cent, and will provide a rapid and simple means of moisture assessment.

Unfortunately, the method, regardless of the apparatus used, is subject to definite limitations. In the first place, it is not practicable to determine a moisture content of over about 25-30 per cent, as the resistance then is so very low. More important, however, is the fact that moisture in timber is often unevenly distributed so that the needles normally used as electrodes, which cannot easily be driven deeply into the wood, frequently tend only to indicate the surface condition, and, what is extremely important, fail to detect a moist centre. The difficulty has been overcome at the Laboratory to some extent by drilling holes in the sample plank and introducing specially designed electrodes, or by cross-cutting the ends and inserting the normal electrodes into the freshly cut section. These methods, however, damage the sample, and one of the main advantages of using the electrical method is thereby lost. Again, it has been found from tests at the Laboratory that not only does the resistance of timber at a given moisture content vary from species to species, but also from piece to piece in any one species. These tests have shown that the variation within even some of the commoner timbers at moisture contents above 15 per cent is so considerable that a very large number of readings has to be made to determine the average correction figure for that species. The impregnation of timber with chemical salts, oils, waxes, etc., affects its electrical conductivity, and so meter readings on treated timber are accordingly subject to error.[1] Despite these drawbacks, however, it may be said that moisture meters,

[1]Electrical-capacity-measuring instruments are subject to similar limitations and errors introduced by variables such as moisture gradients, wood density, and surface contact. These errors often may be quite appreciable.

if used intelligently and with a knowledge of their limitations, have a wide field of usefulness.

The Preservation of Paintings on Wood Panels

In co-operation with the National Gallery, tests have been undertaken with the aim of evolving a practical method of reducing in works of art painted on wood the deterioration which occurs as a result of changes in atmospheric conditions. It is thought that movement and curvature of these panels could be reduced by applying a moisture-proof barrier to the backs, and, as a first step, the relative effectiveness of various materials for this purpose is being investigated.

WOOD BENDING

Much of the work in wood bending has been devoted to determining the bending properties of exotic timbers, in the hope that some of these will prove suitable substitutes for the commonly used bending woods such as beech and ash that now are in short supply. Twenty-five species have been tested, but none, unfortunately, was found to possess bending properties equal to those of beech. The results obtained on these and all other species tested to date have been embodied in a recently published leaflet. The limiting radii of curvature of laminae from these and other species bent in the cold state have been determined, and the influence of the method of conversion has been investigated. Again, none of the timbers tested exhibited bending properties as good as those of the traditional temperate-zone timbers, and the effect of the method of conversion on the limiting radius was found to be insignificant.

At the request of the Timber Control, bending tests were carried out on consignments of Sitka spruce which had been rejected for use in aircraft on the ground that, after a long period of storage, this material had become brittle. There was no evidence from the tests that the spruce had in fact deteriorated, and a report on the findings was submitted.

Interest in the "continuous strip" method developed during the war for making laminated bends continues to be shown by the trade, and the process has frequently been demonstrated on the new vertical revolving table machine (Plate 2). The strip or ribbon of wood (Fig. 1) may be made up to the required length by scarf-jointing assorted lengths of whatever species happen to be available. It is wound on a spider, and the loose end is passed through a glue spreader and is then attached to the form, which may be of any desired shape. The balata belt, which is under tension, presses the strip against the jig somewhat in the manner of a band-brake, as the large vertical table revolves. The strip, which is spread with synthetic glue on one side is thus tightly wound around the jig and conforms to its shape. When the required thickness has been wound on, the resulting hoop is clamped and removed for setting the glue. The machine figured here is the complex fully calibrated model which yields the detailed data for the operation of the much simpler types designed for industrial production.

Miscellaneous tests have been carried out to determine the bending properties of various types of plywood, the causes of fracture in oak used for making barrel staves, and the methods of setting certain furniture bends. A considerable amount of time and work has been devoted to the "shooting" of scenes for a Department film on wood bending.

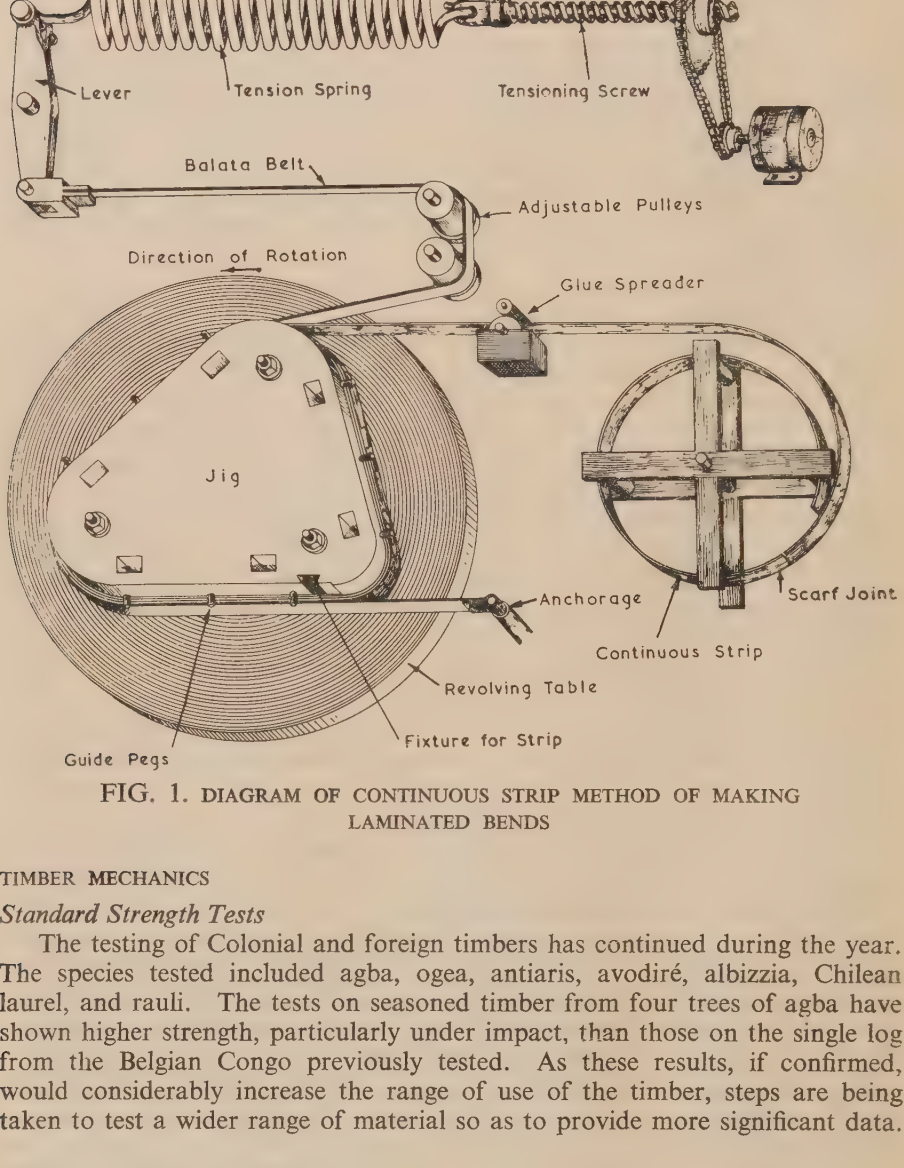


FIG. 1. DIAGRAM OF CONTINUOUS STRIP METHOD OF MAKING LAMINATED BENDS

TIMBER MECHANICS

Standard Strength Tests

The testing of Colonial and foreign timbers has continued during the year. The species tested included agba, ogea, antiaris, avodiré, albizzia, Chilean laurel, and rauli. The tests on seasoned timber from four trees of agba have shown higher strength, particularly under impact, than those on the single log from the Belgian Congo previously tested. As these results, if confirmed, would considerably increase the range of use of the timber, steps are being taken to test a wider range of material so as to provide more significant data.

The Use of Timber in Building

Activity in the building field has included full-scale tests on two timber structures and on several structural units, and considerable time has been devoted to the development of test methods and equipment.

The structures tested included a Dutch barn of shear connector portal frame construction, which was tested in the field in co-operation with the Ministry of Agriculture, and a three-bay portion of a glasshouse based on asymmetrical laminated timber arches, designed by the Timber Development Association for the new establishment of the John Innes Horticultural Research Institution

at Bayfordbury, Herts, and erected at the maker's works in London. Both structures were tested to overload but not to destruction, and both performed satisfactorily. The Dutch barn was subjected to vertical loading at the purlins by means of hydraulic jacks anchored to beams held down by a loaded truck, and to simulated wind-loading by means of a block and tackle anchored to a post and working through a spring dynamometer.

The glasshouse was subjected to distributed vertical loading applied to the glazing bars so as to test all elements of the structure. Loading was by means of hydraulic jacks, five in number, anchored to fixings specially provided in the floor concrete, the individual loads being ganged by means of timbers kindly made available by the firm responsible for the glasshouse. Following the overall test, a further test was made of the arches alone in order to investigate the possibility of using them at greater centres; the necessary additional capacity was demonstrated, though the test was not taken to destruction. A photograph of the glasshouse under test is shown in Plate 3.

At the Laboratory tests have been made on a variety of roof trusses, ranging from light frames of 20-ft. and 25-ft. span for prefabricated storage buildings to a 43-ft. span industrial truss forming part of a series sponsored by the Timber Development Association. This truss, of shear connector construction and having a lower timber content for the rating than hitherto, was the largest tested to date and represented the limit of convenient capacity of the present building and equipment. Following procedure developed previously and reported last year, the truss was set up on pedestals over a pair of steel beams, with side support for the top chord provided by radius arms pivoted on the frame of the test premises. Loads were applied at the ten purlin points by matched hydraulic jacks attached to the steel beams. One of the jacks was arranged to load through a spring dynamometer. The truss failed near the outer end of the lower chord, where the section was reduced by a connector, at a load equal to three and a half times the combined design dead and snow load, which may be regarded as a highly satisfactory result. Preliminary work for the Timber Development Association in connexion with the design of this truss consisted of tests of eaves-joint units made up as simple frames, which were tested in a universal testing machine as illustrated in Plate 4.

Further investigation has been made during the year of the degree of accuracy of load measurement obtainable from the pressure in hydraulic jacks. With a sufficient number of jacks available it was possible to produce matched sets and more consistent results were obtained than with random choice. It was still necessary to transmit the load of one jack through a spring dynamometer in order to obtain true readings of maintained loads, and the accuracy at low loads also left something to be desired. It is now concluded that to achieve satisfactory results it will be necessary to use a pressure capsule in conjunction with each jack. To reduce the number of units involved, adjustable linkages for distributing loads are now being designed in glued-wood and plywood construction. A portable loading plant is being designed embodying hand-pump units and pressure gauges flexibly piped to the jacks and capsules. With these modifications continuous working should be possible with a relatively small staff.

Work has been started to examine the effectiveness of inter-joist strutting in distributing concentrated loads on board and joist floors. A test has been made on a floor consisting of 1-in. thick (nominal) tongued and grooved board-

ing on 2 × 7-in. joists at 18-in. centres with one row of herring-bone strutting, subjected to a concentrated load at the middle of the span of the middle joist. It was found that the effect of the strutting in distributing the load was small compared with that of the boarding. The balance may be redressed somewhat if the thinner boards now advocated for reasons of economy come into use, but as the test floor strutting was probably more accurately fitted than is usual in practice, its performance was probably better than would normally be achieved. A further experiment is planned in which variables will be controlled through a series of tests so as to enable directly comparable data to be obtained covering herring-bone and solid strutting at a range of spacings; this has had to be left in abeyance, however, owing to other demands.

Wearing Qualities of Timber

Standard abrasion tests have been made of several new hardwoods of possible value for wood block and strip flooring. The timbers tested included the following:

Muhimbi (*Cynometra alexandri*) from East Africa.
Musine (*Croton megalocarpon*) from East Africa.
Krabak (*Anisoptera* spp.) from Siam.
Kokrodua (*Afrormosia* sp.) from West Africa.

The first two hardwoods, suggested as substitutes for maple for heavy-duty flooring, showed promise in this respect, muhimbi in particular. Krabak was found less satisfactory for heavy-duty flooring and appears better suited for light to moderately heavy conditions of pedestrian traffic as in domestic and other buildings. Kokrodua, suggested as a substitute for Burma teak for ships' decking, proved satisfactory from the point of view of resistance to wear.

Tests have also been made of (*a*) a patent wood-resin flooring material and (*b*) a special type of end-grain Burma teak flooring.

A bulletin dealing with the studies of the behaviour of softwoods under traffic, reported previously, has now been published*. This publication, together with that dealing with the behaviour of flooring hardwoods under traffic, completes the general analysis of the phenomenon of surface wear for all flooring timbers.

Performance Tests of Doors

Work has continued on the investigations directed towards the establishment of performance tests of doors, the results of which will be used to draft specifications that will replace existing ones based on constructional materials and design; the preliminaries of such tests, including the design of a torsion test, were described in the 1948 Report. While vulnerability under repeated slamming is possibly not a critical consideration, it was felt by the relevant British Standards Institution Committee that this aspect at least warranted investigation. A repetition slamming test has therefore been improvised for exploratory purposes. The door under test is hinged horizontally and allowed to fall freely from the vertical position and to strike a stop corresponding to a door frame when the horizontal position is reached. The severity of the impact is roughly comparable to that which occurs when a door is slammed violently by the wind. The test is run at two cycles per minute. The tests are being made on doors reconditioned after exposure in the humidity trials mentioned earlier in this

* ARMSTRONG, F. H. Flooring Softwoods. *Bull. For. Prod. Res., Lond.*, No. 23. (H.M.S.O.).

report (p. 16), pairs of doors of a type being allocated one to the torsion test and the other to the slamming test. The first batch of doors has been tested. As expected, the more consistent results are obtained from the torsion test, in which flush doors show to advantage, than from the slamming test, early failures in which have been mainly in the face/core gluing of flush doors. Some work has also been done on a simple form of puncture test, with reference to the liability of panels and skins to fail through kicking or similar abuse, but difficulty is being experienced in evaluating the appropriate criteria.

Strength Properties of Sheet Materials

In view of the projected investigation by the Chemistry Section into the manufacture of hardboard, some consideration has been given to the question of the mechanical tests which will be necessary to evaluate any boards produced. This question came up for discussion at the meeting of the Sub-Committee on Mechanical Timber Technology of the F.A.O. at Geneva in September, which was attended by a senior officer. There is a British Standard Specification covering such material, but the tests prescribed are not exhaustive, and the flexural test, which is the only mechanical test, provides for only one length of test piece and permits the use of fixed supports for the piece, thus differing from practice abroad and from the generally accepted methods employed in testing timber, in which the length of the test pieces varies in proportion to the thickness, and the test piece is supported on rollers in order to eliminate the effect of friction. In view of the obvious advantage of a test procedure capable of application to all competitive sheet materials, advantage was taken of the fact that this specification was under review to submit proposals on these lines. The question of length of test piece involved only considerations of principle and could be argued only as such. The Committee decided to confine itself to the requirements of its own specification, and the proposal under this heading was not accepted. The argument for roller supports was in a different category and their advantage was demonstrated to the Committee by a special piece of apparatus in which a flexural test piece under load could be switched from the condition of fixed supports to rollers. It was shown that in measuring deflection within the prescribed range errors due to friction might reach 6 per cent. The Committee accepted the principle of a roller support and it will be included in the revised specification.

The Strength of Mine Timber

Tests have been carried out on props provided by the Timber Control, as follows:—

(i) Some Newfoundland props which had been rejected on arrival in this country, but which proved on test to be superior to the general run of softwood props.

(ii) Sample props of Corsican pine from Italy, which proved to be of acceptable strength.

(iii) *Cupressus* and *Pinus* spp., fast grown and knotty, which proved to be insufficiently strong for mine props; and mfunda, very strong but heavy hardwood props, all from Kenya.

For the Forestry Commission an investigation has been made of props of hardwoods grown in the Forest of Dean and customarily used in mines in the locality. The oak and beech were characterized by marked crook, which

reduced their average strength to a value slightly lower than that of representative softwood. The ash and sycamore were straighter and compared more favourably. The elimination of the more crooked oak and beech props was recommended.

Miscellaneous Strength Testing

Several miscellaneous tests and *ad hoc* investigations have been undertaken, including tests on broken hockey sticks, ladder rungs, hickory stay-wire insulators, and on decorators' platforms wire-braced in accordance with ladder principles. Tests on staves from a fifty-year-old vinegar vat suggested that there had been no significant reduction in strength during this period. A testing service in connexion with the placing of contracts for fibre-board boxes has been continued for the year at the special request of the London representatives of a Dominion Government.

COMPOSITE WOOD

Properties of Plywood Adhesives

The Series II long-term natural durability tests on plywood adhesives are now four to five years old. All but the most durable types of glues have completely failed in the full exposure to weather. Those that still remain show no significant weakening. Comparison is being made between the results with the less durable glues and their behaviour in situations open to outside air, but in which there is protection from direct rain and sun. Time has yet to show whether the greatly improved performance of these adhesives when partly protected is real, or whether breakdown is merely delayed.

The allied trials upon glues for assembly work are between two and a half and five years old. Observations on the Ply-clad frame* and the laminated beam test-units continue, and in general, these give similar indications of durability to the tests on plywood adhesives, but the times to produce comparable amounts of degrade are found to vary widely with the type of joint, and since durability has usually to be expressed in terms of the joint as well as the environment, valuable data are accruing.

There have been two additions to the work on the durability of adhesives, viz. the tropical tests and the marine experiments. The first is in collaboration with the Tropical Testing Establishment of the Ministry of Supply, which has prepared sites at Port Harcourt in Nigeria so that plywood can be exposed to conditions ranging from full sun and weather to storage in sheltered sheds. The marine tests are being made in collaboration with Admiralty Craft Experimental Establishment in H.M.S. *Hornet* at Gosport, where a 70-foot motor torpedo boat has been put at the Laboratory's disposal. On the deck of this (Plate 5) and in various positions within the hull, samples of plywood and built-up units are being exposed, to test the durability of many types of glue. The effectiveness of preservatives in prolonging the life of plywood of non-durable species is also being studied.

For these two projects, well over five thousand samples have been made, a task that has occupied much of the staff's time, for with experiments away

* The details of these frames were given in the Report for 1946. Briefly, they are softwood frames to which are bonded plywood sheets. These have their edges protected in various ways, and each frame is fully exposed to full weathering on one side, and on the other to outdoor air, but not to sun or rain.

(A) THE NEW MODEL KILNS

(B) RADIO FREQUENCY DRYING OF 6 × 6-INCH BEECH

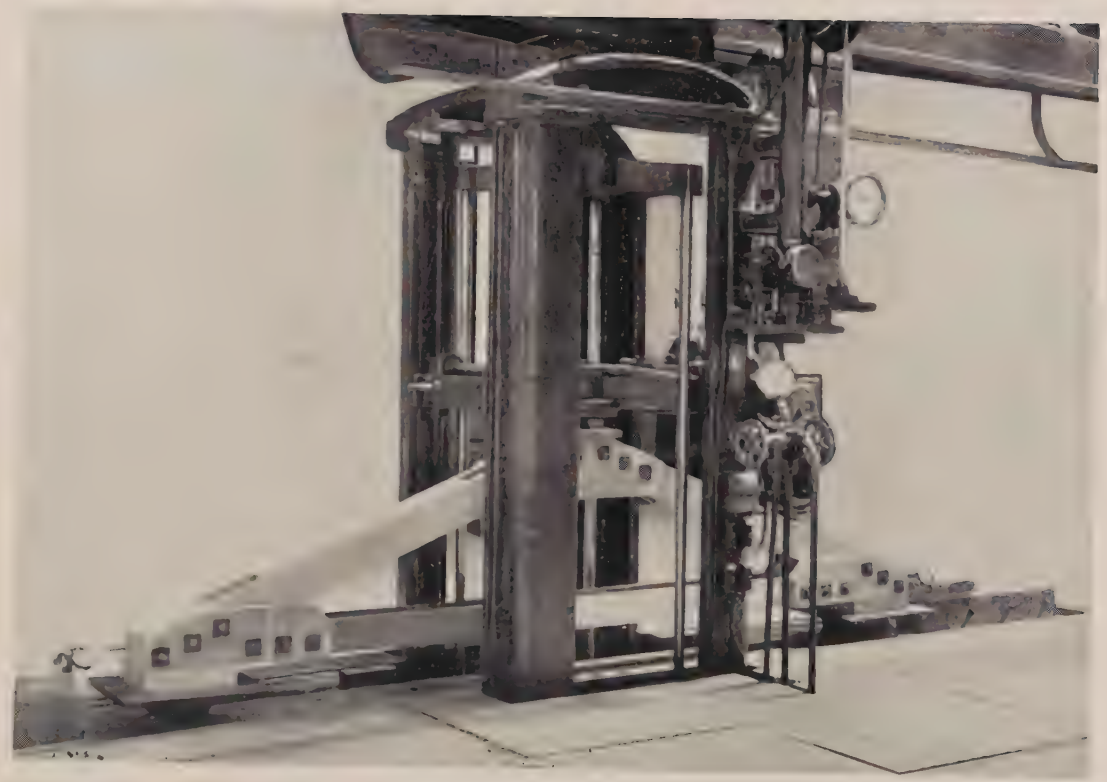
PLATE 1

MACHINE FOR MAKING LAMINATED BENDS BY THE
CONTINUOUS STRIP METHOD

PLATE 2

TESTING OF A GLASSHOUSE OF LAMINATED TIMBER ARCH CONSTRUCTION

PLATE 3



TESTING OF EAVES-JOINT UNITS

PLATE 4

Top right—February 1950: showing the flaking of paint on a sample treated with preservative. No weathering of the glue has occurred.

Main view—Motor torpedo boat in the hull and on the deck of which glued joints are exposed for long-term trials.

Bottom left—Plywood panels "in the white" secured to the deck, August 1949.

TESTS OF DURABILITY OF ADHESIVES IN MARINE CRAFT

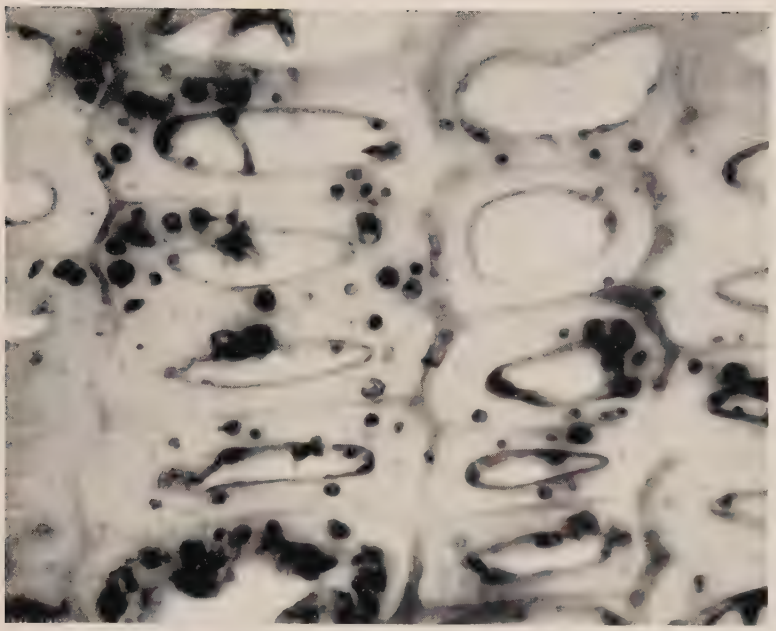
PLATE 5

(*a*) Feed speed 50 f.p.m. showing spiral motion of the sawdust, with finer particles escaping at side of kerf

(*b*) Feed speed 100 f.p.m. showing spiral motion ceasing as the loading of the gullet increases; coarser sawdust produced, with few particles escaping

DISTRIBUTION OF SAWDUST IN GULLETS OF CIRCULAR SAW

PLATE 6



(*a*) Fungal hyphae in the secondary walls of the summerwood elements (× 900)

(*b*) Characteristic cavities in longitudinal section (× 1200 approx.)

BREAKDOWN OF SOFTWOOD TIMBERS IN WATER-COOLING TOWERS

PLATE 7

DAMAGE TO OAK SAPWOOD TILE BATTENS BY *LYCTUS* POWDER-POST BEETLES

PLATE 8

from the Laboratory even more than usual care had to be given to the initial inspection and to the system of marking individual pieces for subsequent identification.

Every opportunity is taken to compare the findings of the systematic trials upon glued joints with the behaviour of similar material actually in everyday use. Through the good offices of H.M.S. *Hornet*, a survey was made possible of over a dozen light naval craft that had been wholly or partly laid up since the end of the war, and much information was obtained on the behaviour of glues under these circumstances.

The Adhesive Makers' Panel continues its work of liaison between the Laboratory and industry. As examples of such can be cited the finding of means to overcome a serious deterioration in the quality of beech slips for glue-testing work, the development, at the request of the Laboratory, of a method of determining gelation times for resin glues, and the initiation of a small-scale survey of the condition of exterior flush doors after several years of service.

Routine work of testing plywood for the Timber Control, and new adhesives for the makers, has continued.

Properties of Plywood

Enquiries received from industrial sources have shown that distortion of plywood during manufacture or immediately afterwards is of not uncommon occurrence, and an investigation into the causes has begun. Although there are many beliefs about these causes there is very little factual information—even on such obvious matters as unbalanced construction, the evils of which have long been stressed. The experiments have embraced such conjectural factors, as well as the systematic survey of the effects at the time of manufacture of moisture content differences between the veneers, of local and general deviation from the traditional lay of the plies at right angles, and of the influence of slack- and tight-peeled veneer on stability. At present, the variables are being examined in boards only 2 × 1 ft. in size, but it is expected that from data obtained from these, many supposed causes of distortion will be found to be without foundation. Factors that seem of importance will be re-examined in boards 5 ft. square, to ensure that scale effect has full play.

Time has not permitted the extension of the experimental work on the cracking of decorative veneer laid on plywood, but many samples of commercial origin have been examined. Several examples of highly polished burr walnut wardrobe doors have shown by their furrowed surface that comparatively narrow cracks present at the time of laying in the surface of the underlying plywood on blockboard can later be fatal to high-class work. The cracks have also shown themselves through the plain mahogany veneer that backs such doors, but without the high polish the defect is not so noticeable.

Observations on the proneness of different species to surface-check when exposed to the weather in plywood form have been continued. To this has been added the study of plastic and paper films bonded to the plywood's surface to protect it from weather and to prevent splitting.

Special Heating Methods for Setting Glues

Mains Voltage Heating. The application of mains voltage heating to cold presses, to accelerate the setting of glues in veneering, was studied with small

units in 1948 and showed such promise that the necessary examination of large-scale effects was put in hand. Tests on a caul 60 × 42 in. brought to light a tendency to uncontrolled rise in temperature, leading to blistering, in those parts which projected, as they must in practice, from the edges of the stack of panels. This was attributed partly to the use of iron wire (which increases in resistance with rise in temperature) and partly to the presence of residual volatile matter in the plastic sheet. The defect was entirely eliminated by the substitution of constantan wire and a modification of the pressing technique when manufacturing the caul in a plywood press. As an additional safeguard, the maximum recommended loading of the cauls has been reduced from 600 to 400 watts per sq. ft., and a large caul so constructed has behaved satisfactorily in a series of test runs.

Besides the development of the heating elements the work has included a study of the penetration of temperature into glued veneers under conditions of constant power input (in contrast to the constant temperature conditions of steam-heated presses), from which practical pressing schedules have been derived. A report on the process has been published.

Low Voltage Heating. Low voltage heating is electrical resistance heating effected by passing heavy alternating currents, derived from a step-down transformer, through sheets of metal and is being investigated as an alternative to mains-voltage heating for accelerating the setting of glues. In principle it is identical with "strip-heating", long used in our bending work in its application to narrow laminated bends. The concomitant study of the penetration of temperature generated over large areas has already been covered in the mains-voltage heating work previously mentioned.

The investigation centres, therefore, on the practical matter of adapting the process to the plant and conditions obtaining in plywood and veneering factories, that is, on the mechanical and electrical problems of handling large currents and studying their behaviour in flowing through wide sheets of metal.

Pending the arrival of plant, essential theoretical investigations were made, such as on the minimum necessary size of the electrodes (i.e. the copper bars fastened across each end of the heating element), to ensure that they distribute the current uniformly to the sheet. It has also been shown that if simple slotting of the sheet is resorted to as a means of causing the current to take a zig-zag path, severe overheating must occur near the end of each slot, and means of overcoming this are receiving attention. The plant has now been delivered and fitted with control gear and auxiliary plant constructed at the Laboratory.

Radio Frequency Heating. One of the chief advantages of the "glueline" method of applying radio frequency heating is its great economy in electrical energy, for heat is generated in the glue itself, in contrast to the "transverse" method in which it is developed in the wood. The power consumed by a joint set by the glueline method is therefore of importance. The conditions applied to the joint, however, must be defined in terms of voltage, and an attempt was made to evolve a way of measuring the radio frequency power delivered to a glueline at a given voltage. The method as such has proved disappointingly troublesome to apply and the work has been concluded, but the applications which were made have yielded fruitful results by indicating the electrical properties essential to glues intended for setting by the glueline method; for the urea

resins, for example, higher electrical conductivities than those now obtaining would be beneficial.

In a previous Report the need was mentioned for developing a standard testing technique for joints set by radio frequency. The softwood sample originally used would only detect gross degrade of the glue, and a more searching testing medium was sought. The erratic results obtained with hardwood samples were found to be attributable to incorrect orientation of the grain, and a standard test sample of home-grown beech has now been developed, taking the form of a short length of laminated beam, made with the grain converging slightly towards each glueline, and tested by endwise splitting. A grading system has been evolved for assessing the quality of the broken joint by visual inspection. While this still leaves something to be desired, it has provided a much needed technique for evaluating joints between solid wood members, irrespective of the method of setting, and has applications in several other investigations.

In its application to joints set by glueline heating, the method has shown that degrade, compared with cold-set joints, can occur with all types of resin glue, although some brands of urea resin appear to suffer but little immediate deterioration even when set in only one or two seconds. The long-term effect, however, has still to be determined, and as a preliminary to these ageing tests the extremes of behaviour of glues under radio frequency heating are being studied.

The Radio Frequency Panel has met during the year to discuss the work in progress, and the scope of the Panel has now been broadened to include all electrical methods of heating applied to composite wood products.

The Plywood Plant

The preparation of the plywood for the tropical weathering tests and the boat work brought all the plant into use, and enabled further studies of its behaviour to be made. For example, a run of large-diameter makoré logs, each extensively damaged by multiple heart-shakes, gave much trouble in peeling, for the veneer was too broken to spool and yet had to be handled in wide pieces. Plans to deal mechanically with this type of out-turn have therefore been made.

The systematic study of cutting angles and knife setting and their effect on peeling has continued, and an interim report has been considered by the Plywood Research Panel.

Studies of the breather-press type of veneer dryer continue, especially on the relative importance of the several parts of the cycle. A ciné camera has been used to time the various stages and to analyse the actual movement of the plates. Steam consumption of the Laboratory's dryer is only about 1·8 pounds per pound of water evaporated, but a study of the air movements in and around the machine hints that further improvements are possible. A matter allied to the drying of veneer is the speedy determination of the moisture content of the product. Electrical meters having proved unsuitable for this type of work, high-temperature ovens with fast air circulation were tried using both steam and electrical heating. These enabled moisture contents to be determined in about ten minutes, but were cumbersome to install and operate. The plant now under trial has a small chain conveyor to make the timing automatic and the operation continuous and employs infra-red heating troughs.

Perhaps the major task of the year has been the evolution of a scheme of yield measurement as a means of assessing quantitatively the suitability of a species for plywood manufacture. The aim is to find the losses at each stage of manufacture, e.g. from billet to green veneer, in clipping or by shrinkage during drying. The scheme also provides a standard target in the processing of dried veneer into finished plywood, and the worth of the species can be gauged from the work entailed in producing the grades and proportions of plywood required by the target figure. Clearly, the methods should be easy to follow and the figures readily convertible to different bases for the scheme to be comparable with and applicable to the many used in industry. With the assistance of the Plywood Research Panel, a scheme was evolved, modified after preliminary work, and is now undergoing its final trials.

Services to the British Standards Institution in plywood matters have been wider than usual, and assistance has been given in preparing specifications for veneered panels, joinery work, glue test slips and marine plywood. The work on glue slips was lightened for the Institution by the prior discussions of the Adhesive Makers' Panel, and the revision of the marine plywood specification was suggested by the Laboratory from the results of experimental work on the durability of adhesives.

The Corresponding Committee on composite wood set up by the Empire Forestry Conference in 1947 has circulated two sets of papers within the year. Fields of discussion have been defined and agreed, and a few particular subjects selected for early attention.

WOODWORKING

Research in Sawing and Machining

Research in ripsawing has been continued during the year. The influence of hook on the power required by a circular saw and on the resistance to feeding at different depths of cut has been determined for two species. A point of interest was that the power demand decreased by about one per cent for each degree increase in hook, irrespective of the depth of cut. An investigation was started on the behaviour of sawdust in tooth gullets under a wide range of cutting conditions. A special technique has been developed for recording by high speed photography the distribution and movement of the sawdust in and around the gullets of saws while the latter are cutting. This class of study has been attempted elsewhere, but the methods used have involved stalling the saw and opening up the wood for inspection of the gullet contents, which gives an erroneous picture. The photographs (Plates 6(*a*) and (*b*)) show the distribution of sawdust in the gullets of a 26-in. diameter circular saw, with 54 teeth, 20° hook and a rim speed of 10,000 f.p.m., cutting English oak at 12 per cent moisture content.

Investigations in rotary planing have been confined to experiments to determine the relation of depth of cut to power demand and feed resistance over a range of feed speeds, but with spindle speed and cutting angle constant.

Preliminary studies in boring and drilling operations have been begun. A standard drilling machine has been adapted for exploratory work on the forces exerted by the cutting tool, and dynamometers for measuring thrust and torque have been designed and constructed for use with this machine. A special feeding mechanism has been devised and is under construction.

General Work

Standard tests have been carried out to determine the woodworking properties of the following species:—

Afzelia (*Afzelia africana*) from Nigeria.
Daniellia (*Daniellia ogea*) from West Africa.
Albizzia (*Albizzia ferruginea*) from Nigeria.
Antiaris (*Antiaris* sp.) from West Africa.
Red oak (*Quercus rubra*) from Forest of Dean. (Limited tests.)

A special experimental conversion has been carried out on a consignment of home-grown oak from the Forest of Dean, which was later used for framing and panelling in the new building of the Department of Forestry, Oxford. A consignment of home-grown beech has also been converted to special sizes and used for various fitments in the same building.

Commercial trials of hardwoods for utilization in spool manufacture continue and a quantity of white cedar blanks has been prepared for this purpose.

A brake dynamometer has been designed and constructed for the experimental saw bench.

Sawmilling Studies in Northern Rhodesia

An investigation yielding valuable information on the sawing of refractory timbers was carried out at the request of the Governor of Northern Rhodesia on the sawing of dry and fire-killed logs of 'Rhodesian teak' (*Baikiaea plurijuga*). Large areas of 'Rhodesian teak' forest in Barotzeland and neighbouring districts have been destroyed by fire during the last century and they contain a considerable volume of dead standing trees and half burnt logs. This material is, in general, dry, hard and of abrasive nature and has been left almost untouched by the sawmillers as too troublesome to saw. It has been estimated that several million cubic feet of timber might be utilized if a suitable technique of sawing could be found.

The investigation was carried out in two stages. The first consisted of exploratory tests at the Laboratory to study possible techniques for the conversion of the 'Rhodesian teak', and the second and more important stage, of the actual trials under conditions of full-scale production in Northern Rhodesia.

A consignment of twelve logs, comprising eight fire-killed and four green logs, was sent to the Laboratory by the Conservator of Forests, Northern Rhodesia, for the exploratory tests. Early consideration of the problem had indicated that it would be necessary to use hard-tipped inserted saw teeth for dealing with this class of refractory timber, and arrangements had been made to obtain sets of teeth tipped with two grades of Stellite and a set which had been tip-hardened by heat-treatment. Stellite—a very hard alloy of cobalt, chromium and tungsten—was chosen as the most promising material for use in hard-tipping as it has a high resistance to abrasion and is of moderate cost. It can be deposited on teeth by means of oxy-acetylene welding and can be ground by ordinary methods. These sets of special teeth and a set of standard quality teeth were used in saws for a series of controlled experiments on the various logs. The performance of the special teeth was assessed upon the output obtained during the period between re-sharpenings, as compared with that given with the standard teeth. It was found that teeth tipped with Stellite Grade 1 and tip-hardened teeth both produced more than six times the

output obtained with standard teeth, and that those tipped with Stellite Grade 12 gave nearly a five-fold output.

The Zambesi Saw Mills (1948) Ltd. provided facilities and a supply of dry and fire-killed logs for the full-scale production tests. Stellite and tip-hardened teeth of sizes appropriate to several types of machine in the mill had been specially prepared and were taken out to Rhodesia for these trials. Although the machines were not in first-class condition, the results of the tests showed that considerable advantage accrued from the use of the Stellite-tipped teeth. Teeth which had been tip-hardened by heat treatment were found unsuitable in the absence of the correct grinding technique.

Experiments were carried out to find the most efficient form of tipping for new and used teeth. An improved method of preparing the teeth and depositing the Stellite was evolved, and sets of teeth were produced in the mill itself for testing on the various machines. The results of these tests showed that the teeth tipped with Stellite Grade 1 gave from five to seven times longer service than standard teeth, before re-sharpening was needed. In some instances where working conditions were favourable the comparative performance was in the ratio of ten to one. The experiments also gave an approximate estimate of the cost of Stelliting and showed conclusively that with this extra cost included, a considerable nett saving was possible because of reduced tooth consumption.

Advice was also sought regarding methods of improving production and promoting economy in timber consumption in the Colony. This involved studies of machines and current practices in the mill and plywood factory of the Zambesi Saw Mills and of the sawmills and workshops of the Nkana, Nchanga, Mufilira and Roan Antelope Mines in the Copperbelt Area. Saw maintenance, machine operation and possible means of improving production were discussed in detail with mill managers and 'saw doctors' and recommendations made with a view to effecting economies in labour and material in all the mills concerned.

Discussions also took place at Livingstone with the Conservator of Forests, Southern Rhodesia, and representatives of the Rhodesian Native Timber Concessions Ltd., Bulawayo, on sawmilling practice. Methods of improving production in the sawmills of the company and the technique for dealing with 'Rhodesian teak' and other dense hardwoods were discussed in detail.

WOOD PRESERVATION

Testing of Wood Preservatives

There is no certainty that coal tar creosote, which is still the most widely used preservative for the treatment of external timbers, will always be available in sufficient quantity to meet the demands for this purpose. It is at present a surplus by-product of the coal-gas and coke oven industries. If alternative uses such as for fuel or as a raw material for other chemical products were developed, it is possible that the cost and availability of creosote would be such as seriously to affect its use in wood preservation. It is therefore desirable to anticipate such a possibility and to obtain information on the efficiency of alternative oil-type preservatives for pressure application. The only practicable alternatives at present are toxic materials dissolved in a cheap non-toxic oil such as fuel oil. A start has been made to evaluate these by putting under test

solutions of pentachlorophenol and copper naphthenate in petroleum fuel oil, and impregnated specimens are now under test in the ground at two test sites.

There is practically no information, essential in developing the technique of preservation, as to how the life of wood treated with preservative is related to its concentration in the wood. This is particularly true with water-soluble preservatives, where the tendency in commercial treatment is to vary the strength of the solution according to the permeability of the wood and the use for which it is intended. The result of this is that although a constant specified amount of salt may be injected, the concentration of the salt in the treated part of the wood may vary considerably. It is therefore desirable to have service data relating service life with concentration. Moreover, the concentrations used in commercial practice are decided largely by economic considerations, and there are therefore no service data available on the use of concentrations outside this range.

An additional method for testing wood preservatives has therefore been started. It consists of treating samples of Corsican pine sapwood and beech, both of which can be completely impregnated, with a number of concentrations of preservatives, starting near the toxic limit and extending well beyond the concentration used in practice.

It is hoped, also, that if a relationship between life and concentration can be established at the lower concentrations it will be possible to foretell, to some extent, the performance of the higher concentrations by extrapolation without waiting for actual failure of all the specimens.

Fire Resistance

The fire hazard of wood depends mainly on its inflammability, but it is also influenced by the ignition temperature of the charcoal formed when wood is heated. As there is very little information available on this property, a series of ignition temperature measurements on a number of different species of wood has been carried out. It has been found that this property varies a great deal from one kind of wood to another, but so far the factors responsible for this variation have not been identified. The ignition temperature of any one species, however, is not constant, but has been found to vary with the temperature at which the charcoal is formed. This variation with carbonizing temperature is regular and much greater than the variation between different species. In addition it has been found that ignition temperature also varies regularly with the period of carbonization.

The method used for these determinations consists of exposing specimens to a series of constant known temperatures and observing the minimum temperature at which ignition occurs. This procedure is tedious and probably for this reason is very rarely used, but it is believed to give truer results which are in closer accord with the behaviour of wood in actual practice.

In connexion with an investigation recently carried out into the inflammability of wood, the permeability to air of about a hundred different species of wood has been measured. Very little is known of this particular property and since it is of value in other fields, particularly in wood preservation, the work is being continued.

Impregnation of Refractory Timbers

The main technical barrier to further progress in the preservation of wood

is the natural impermeability of so many of the timbers requiring treatment. At the present time, work in this field is being carried out mainly with Douglas fir, which is one of the most difficult structural softwoods to treat satisfactorily with preservatives. The various factors involved in the pressure treatment of these woods, such as the pressure cycle and temperature of preservative, are being systematically investigated in order to find the most effective treatment schedules. Some progress has been made in this direction, but it has been found that there are factors influencing the treatment which have still to be identified, and it is difficult to carry out systematic studies until this has been done.

Marine Timbers

Previous tests by the Sea Action Committee of the Institution of Civil Engineers showed that a copper-chrome preservative was very effective in preventing the attack of timber by marine borers. At Singapore this preservative gave results as good as those from creosote, but unfortunately the samples at Colombo were lost after 2 years' exposure. The samples at Singapore are still under test, but the Committee has considered that the results should be confirmed by a further series of tests, and it was decided to repeat the tests at Colombo and Singapore and to include an additional one in home waters.

The Laboratory is co-operating closely with the Committee in this work and is arranging to prepare the necessary samples.

MYCOLOGY

Additions to the collection of cultures of wood-inhabiting fungi have been made and a new catalogue of the strains available has been prepared. An increasing number of requests for cultures has been received, both from other research laboratories and from industrial firms who wish to carry out tests on wood preservatives or who are investigating antibiotics from fungi.

Owing to the unusually dry season, little collecting in the field was possible, but useful additions to the herbarium have come from mycologists in Portugal, Austria and the Argentine. Dr. Lohwag, an Austrian mycologist who spent several months at the Laboratory while holding a bursary from the British Council, collected for the Laboratory a specimen of *Polyporus quercinus* at Woodstock, an extremely rare fungus that has not been seen for many years. Dr. Lohwag also prepared a series of photomicrographs illustrating the effect of various wood-rotting fungi on the cell walls of different timbers and demonstrated that the tangential walls may be destroyed by certain fungi before the radial walls in the same cells are reduced in thickness.

Dry Rot in Buildings

The small exhibition mentioned earlier in this Report, on the recognition, treatment and prevention of dry rot was prepared with the assistance of the Exhibition branch of the Department and shown in September and October at the Building Centre in London on the invitation of its Director. This exhibition aroused so much interest that it was decided to show it elsewhere and it was sent to Belfast and later to Glasgow. In both of these cities it was visited by a large number of people and received considerable publicity in the press. It has been decided that a mobile exhibition on dry rot and woodworm should be set up

with the assistance of the Central Office of Information and exhibited during 1950-1 at the principal cities of Great Britain. The film illustrating the recognition and treatment of dry rot has been completed and a number of copies have been sold. It has been shown at the various exhibitions and at several lectures.

Further work has been carried out in co-operation with Building Research Station on fungicidal renderings for application to walls infected with dry rot. It has been found that the addition of cuprous oxide to a magnesium oxychloride cement renders it sufficiently toxic to prevent any outgrowth of *Merulius lacrymans* when the rendering is applied to blocks heavily infected with the fungus. Paints and renderings based on zinc oxychloride have also proved toxic to this fungus. A report on the tests is being prepared for publication and it is now proposed to carry out trials with these materials under practical conditions.

Several occurrences of dry rot in woodwork of houses built since the war have been inspected and possible causes suggested. The use of unseasoned wood is likely to have more serious results when placed in a solid floor than in a well ventilated suspended floor, where further drying out *in situ* is possible. For this reason it is most desirable that the wood to be laid on solid floors should be treated with a preservative beforehand. It is often stipulated that no impervious coverings should be laid on a new solid floor until 6 or 12 months after its construction, but in practice it is difficult to ensure that such orders are observed. Thorough treatment with preservative will afford protection even if the boards remain in a damp condition for a considerable period.

Breakdown of Timber in Water-cooling Towers

It is well known that the timber filling of water-cooling towers undergoes a form of deterioration which progresses inwards from the exposed surfaces of the individual pieces of wood. Chemical analysis has shown that this deterioration consists essentially of a hydrolysis in which preferential attack is made upon the cellulosic portion of the cell walls of the wood.

Hitherto it has been assumed that this hydrolysis is caused solely by the action of heated water, but observations made during the last two years tend to show that fungal activity may also contribute towards this breakdown. The fungi concerned are not species which have previously been recognized as wood-destroying types, and no indications of the presence of the wood-destroying Basidiomycetes have been obtained.

It has been found that in the outer layers of the sound wood (that is to say, just below the very soft blackened surface layer of decomposed wood) fungal hyphae are always present in the thickness of the secondary walls of the summerwood elements (Plate 7(*a*)). These hyphae pursue a characteristically spiral course, the pitch of the spiral varying with the species of wood concerned, but in all examples the hyphae have been shown (viewed in longitudinal section) to lie in cavities with characteristically pointed ends (Plate 7(*b*)). These cavities appear to be joined in chains by very narrow lengths of hyphae which run between them. The sharply pointed ends of the cavities are in themselves an indication that enzyme action has taken place. Bailey and Vestal have previously described similar cavities found in a wide range of timbers and concluded that unknown fungi, probably Ascomycetes, were the cause.

Towards the surface of the timbers of the cooling-tower, increasing dissolution of the central part of the secondary thickening of the summerwood cell walls is found. Finally the inner part of the wall can be seen as a ring of tissue entirely separated from the remainder. Spirally orientated hyphae are also found in the springwood elements but here they appear to lie free in the lumen of the cell as no perforations of the walls have yet been found. When they are plainly visible the appearance of the hyphae suggests that they belong to members of the Ascomycetes or to Fungi Imperfecti. Barghoorn and Linder, working on timber and cordage obtained from the inter-tidal zone on the seashore, isolated a number of new Ascomycete genera and described similar breakdown of the wood. Their view was that the breakdown was only of importance where the softened surface was continually removed by the scouring action of the tides.

Isolations made from the timbers have yielded a variety of fungi of the above-mentioned groups, together with much bacterial contamination. The species of fungi isolated have not all been identified. However, among the Ascomycetes, *Chaetomium globosum* and *Orbicula spadicea* have been positively recognized and some of the other isolations appear to be Ascomycetes which normally live in the bark of fallen trees and branches. Yet other isolations, e.g. of species of *Phialophora*, are of fungi which cause blue staining of wood. Hyphae which can be identified as belonging to wood-staining species are always present in the slats.

Unusual conditions are present in the cooling-towers. The overall temperature, 70-90°F., is suitable for supporting a wide range of plant growth, the water passing over the timbers is very well aerated and no doubt the aeration of the wood surface is greater than would normally obtain for water-logged wood. Growths of green algae and diatoms are present on the surface. At these temperatures their growth and subsequent decomposition by bacteria will be rapid and some of the products of decomposition are no doubt available to the fungal population as food material. Bacteria are often found in the surface layers of the wood, and they are most noticeable in areas where there has not been marked fungal attack. It is not known whether or not their presence has any significance.

Of the fungi isolated, *Chaetomium* is known as an active cellulose destroyer. The layers of summerwood walls attacked are those thought to contain nearly pure cellulose, and the regions believed to be more heavily protected by lignification are not affected. On the other hand, *Orbicula*, whilst often recorded as growing on cellulosic materials, is reputed to be best sought for near the charred areas of partially burnt wood, i.e. on wood already partly hydrolysed by heat.

Whilst no conclusion has been reached that the fungi observed in, and isolated from, cooling-tower slats are the primary cause of the breakdown of the wood, it is clear that even as secondary agents attacking partly hydrolysed wood they can play a part in increasing the rate of deterioration.

Physiology of Wood-destroying Fungi

A paper summarizing the results to date of the experiment to determine the length of time wood-rotting fungi can remain alive in a dormant state in air-dry wood has been prepared and accepted for publication in *Forestry**. The

* FINDLAY, W. P. K. Resistance of Wood-rotting Fungi to Desiccation. *Forestry (In the press).*

experiment is being continued. So far two species of *Lenzites* have survived for 5½ years at 25°C. in wood kept at about 12 per cent moisture content.

Dr. Birkinshaw at the London School of Hygiene and Tropical Medicine is continuing his investigations into the metabolic products of cultures of wood-inhabiting fungi supplied by the Laboratory. A paper on the metabolic products of *Endoconidiophora* species is now in the press. The investigation of the products of *Polyporus benzoinus* is nearly complete.

Decay of Timber in Ships and Boats

Judging from the number of enquiries received, there is a need for more information about the prevention and treatment of decay in wooden craft. During the war large numbers of vessels were constructed of wood for the Admiralty and in some of these there has been extensive deterioration, particularly in craft laid up in reserve. Fourteen of these larger craft were carefully examined throughout by one of the Mycology staff and a detailed report on their condition has been prepared. The principal cause of decay was traced to leakages of fresh water. The fungus most commonly found was *Coniophora cerebella*, but species of *Poria* were also observed on a number of occasions.

In the past little use has been made of wood preservatives on timber in boats and it would seem desirable to extend such use. At the present time it is sometimes difficult to obtain supplies of teak and seasoned oak heartwood, with the result that other less durable woods may be employed. If plywood is used, the material generally available is made from non-resistant timber and requires protection even if the glue used is a synthetic resin, which is resistant to breakdown.

An inspection of the old wooden warship H.M.S. *Implacable* was made before it was decided to sink her, and it was found that her timbers were so severely decayed above the water line that had it been decided to repair the vessel almost complete reconstruction of the parts above the water-line would have been necessary.

Suggestions for preventing decay in woodwork in cool rooms on warships have been sent to the Admiralty.

Sap-stain Investigations

Complaints had been received about the presence of dark-coloured streaks in kiln-dried oak destined for the new House of Commons and a quantity of this timber was inspected. It appears from subsequent investigation that the considerable variation in colour which is fairly common in oak seasoned either by air-drying or in a kiln may be due to translocation and re-disposition of the tannin present in the wood.

All samples of imported timber showing sap-stain which are received at the Laboratory are examined and, when it is possible, pure cultures of the causal fungi are isolated and identified. In this way information is being collected as to the fungi responsible for the staining in these woods. Rapid deterioration of the logs of many light-coloured softer hardwoods by sap-stain is one of the major difficulties experienced in utilizing some of the species. Application of a suitable combined insecticidal and fungicidal solution to the logs *immediately* after felling appears to afford considerable protection against damage by staining fungi and borers, and experimental treatments have been undertaken in a number of Colonies.

Laboratory Tests on Resistance of Timbers to Decay

The resistance to fungal decay of the following timbers has been examined by the usual laboratory method: mtondo, mchenga, mora, morabukea, avodiré and *Afrormosia* sp., this last-named being found to be highly resistant.

Standardization. Correspondence with other Laboratories is in progress about the possibility of carrying out co-operative tests with a view to standardizing laboratory methods of testing the natural decay-resistance of timbers. It is, for instance, evident from preliminary experiments that the size and shape of the test pieces may influence the amount of decay caused by any test fungus during a given period. For example, in one experiment beech blocks exposed to *Polystictus versicolor* for 8 weeks at 22°C. lost weight as follows:—

Size of block (cm.)	*Loss in dry weight* (per cent)
10 × 2·5 × 1·25	21·1
5 × 2·5 × 1·25	31·5
5 × 2·5 × 0·5	49·1

If, therefore, it is wished to compare directly results obtained in one Laboratory with those obtained in another, it is obviously desirable that some agreement should be reached on the size and shape of the test pieces and other matters.

Toxicity Tests of Extractives from Timbers. The resistance to decay of various durable timbers has been attributed to the existence in them of various extractives toxic to fungi. Most of the extracts so far tested have been made with water and it would be of interest to examine extracts made with alcohol and other similar solvents. Through the courtesy of Professor F. E. King, of Nottingham University, alcohol extracts of several durable timbers have been received for test. In general, the alcohol extracts appear to be less toxic to fungi than the water extractives, but a great deal of information is necessary before general conclusions are possible. It is proposed to examine the toxicity of aqueous extracts from as many durable timbers as possible.

The resistance to attack by dry rot fungi of a further number of wall boards made from wood waste and flax shives has been tested at the request of the Building Research Station.

Laboratory Testing of Wood Preservatives

Further proprietary wood preservatives have been tested by the standard method at the request of their manufacturers. The toxicity to wood-rotting fungi of copper lanolate prepared from acids derived from wool grease has been tested and found to be insufficiently high to make this material suitable for the preservation of wood.

Possible improvements in the technique of carrying out laboratory tests on wood preservatives have been studied. The use of soil in place of an agar medium on which to grow the test fungi has been recommended by several workers. Preliminary experiments indicate that only some types of soil provide a satisfactory medium and it appears that the alkaline soil of this locality is not favourable for the growth of the test fungi. The difficulty of obtaining a soil of constant composition militates against the use of this material in standard tests that may have to be carried out in any part of the country. Vermiculite

soaked in a nutritive solution may provide a useful alternative and the vigour of cultures on this medium is being examined.

One of the difficulties experienced in other laboratories where the relative humidity of the atmosphere is very low at certain periods of the year has been rapid drying-out of cultures in Kolle flasks, and the use of round screw-top bottles as culture vessels has been suggested. These have the advantage of being more readily obtainable and less expensive than Kolle flasks. Decay of the wood blocks by certain fungi, in particular by *Coniophora cerebella*, was rather better in the bottles than in Kolle flasks, but other fungi seem to do better in the Kolle flasks. Further comparative work will be necessary before any decision is reached about changing the type of the culture vessel, but when difficulty is experienced in obtaining Kolle flasks or in keeping them moist, bottles with metal or plastic screw-on tops provide a useful alternative.

Complete penetration of test pieces with preservative is necessary to obtain even distribution of the toxic material through the wood. Experiments have been carried out to find whether cutting the blocks with the long axis at right angles to the grain so as to expose more end grain will give better impregnation with the standard treatment than when the long axis is parallel to the grain.

A new and simpler technique has been devised for testing the toxicity of volatile compounds to fungi, and a number of new organic compounds have been tested in comparison with substances such as formaldehyde and xylene, whose vapours are known to be toxic to fungi. A further range of compounds is being examined.

Mycological Enquiries

Most of the enquiries received refer to the treatment or prevention of dry rot in buildings, and many inspections of affected buildings, including a number of churches, have been called for. Again, many enquiries have been received about the cause of decay in wooden boats and ships and it is evident that naval architects and shipwrights are becoming increasingly interested in this problem. Many samples of new timbers showing unfamiliar types of fungal deterioriation have been submitted for examination, and advice has been sought as to the means of preventing deterioration of perishable timbers after felling. Interest has been shown in the possibility of using composted sawdust for manure.

As examples of the more interesting and unusual enquiries the following may be quoted: cause of breakdown in thatchboard used for roofing in Iraq, decay in tannin storage vats, decay of woodwork of an ambulance in Borneo, rotting of wooden packing cases inside hermetically-sealed metal boxes, and treatment to prevent decay of oak half-timbering in Elizabethan houses.

CHEMICAL INVESTIGATIONS

The Saponins of the Heartwood of Mora (Mora excelsa)
and Morabukea (M. gonggrijpii)

A constitutional study of the sapogenins derived from mora saponin first described in the 1948 Report is being undertaken by Dr. D. H. R. Barton of the Imperial College of Science and Technology, who has found that the principal component of the mixture is a pentacyclic triterpenoid hydroxy-carboxylic acid which has not hitherto been described and for which the name "morolic acid" is proposed.

In a study of the distribution of saponin in the heartwood of mora it has been found that, in any single tree, the saponin content tends to be rather greater in the upper than in the lower portion of the stem. There is considerable variation in overall saponin content between tree and tree, the minimum content encountered being 2·8 per cent and the maximum 9·6 per cent of the dry weight of wood.

Systematic fractional crystallization of the mixture of mora sapogenins yielded four main products. One of these is morolic acid, one is probably oleanolic acid, and the other two are mixtures. It has been found experimentally that morolic acid, $C_{30}H_{48}O_3$, m. pt. 269-270°, crystallizes with one molecule of alcohol and that the latter is removed on heating at 160° *in vacuo*. The equivalent weight of morolic acid and the acetyl content of its acetate are in agreement with the view that it is a monohydroxycarboxylic acid.

The saponin of morabukea heartwood was isolated in 4·1 per cent yield on a dry wood basis. Only one well defined sapogenin was obtained from this saponin. Found for the sapogenin m. pt. 298-300°, $\left[\alpha\right]_D^{20°}$ + 74·0° (c = 2·02 in chloroform) and, for the acetate of the sapogenin, m. pt. 266-267°, $\left[\alpha\right]_D^{20°}$ + 73·5° (c = 2·19 in chloroform).

This sapogenin is very similar in its properties to oleanolic acid, but its identity has not been definitely established.

Although the principal sugars obtained on hydrolysis of both of the above-mentioned saponins are glucose and xylose, partition chromatography has revealed that mora saponin yields minor amounts of two other sugars, namely a hexose and a pentose. The unknown hexose and pentose were also found in the hydrolysate of morabukea saponin in admixture with very small amounts of two other unidentified sugars. It is possible that those sugars found to occur in traces in the saponin hydrolysates may have been derived from impurities such as wood hemicelluloses rather than from the saponins themselves.

A note on the saponins of mora and morabukea has been prepared for publication[1].

The Starch and Related Polysaccharides of Certain Hardwoods

Investigation of the granular starches isolated from the sapwood of English oak, Turkey oak, maple and elm has been continued in conjunction with Professor E. L. Hirst and his collaborators in the Chemistry Department of the University of Edinburgh. From an analytical point of view, tannin has proved to be the most troublesome impurity in all of these preparations, since it interferes with the reactions used in the characterization of starches. For example, tannin was found to oxidize potassium iodide with the liberation of free iodine so that, in order to determine the amylose content of wood starch by potentiometric iodine titration, the free iodine liberated by the tannin impurity had first to be removed with dilute thiosulphate. Lignin and anthocyanin were found to be minor impurities in wood starch preparations which also interfere in reactions typical of pure starches. In the periodate oxidation used to determine

[1] Farmer, R. H., and Campbell, W. G. Isolation of a Saponin from the Heartwood of the Mora Tree and of a Related Species Morabukea. *Nature*, 1950, **165**, 237.

the chain length of the "laminae" of the amylopectin components of wood starches, low results were obtained, owing to the production of excess acidity by these impurities and by tannin in particular.

When due allowance is made for interference by the impurities referred to, it transpires that the amylose content of wood starches is of the order of 12-20 per cent and that the chain-length of the amylopectin fraction is of the order of at least 14 anhydroglucose units. It thus appears that wood starches are constitutionally comparable with cereal and root starches other than the "waxy" starches, which latter contain only negligible proportions of amylose.

Investigation of a Crystalline Substance found in Peroba de Campos Wood (Paratecoma peroba)

In investigating a recent case of dermatitis attributed to dust from this wood, a commercial firm observed a white crystalline substance on exposed surfaces of several pieces of the wood after machining and submitted samples for investigation. Examination of these, as well as of samples of peroba de campos from other sources in this country, revealed that this crystalline substance was present in all of them. It was readily isolated from the wood by steam distillation and purified first by washing with dilute aqueous sodium carbonate to remove lapachol (a yellow colouring matter of common occurrence in woods of the Bignoniaceae, to which family peroba de campos belongs), then by repeated recrystallization from alcohol, washing with water, drying over phosphorus pentoxide and finally by sublimation *in vacuo*. The pure substance which was obtained in yields of the order of 0·7 per cent of the dry weight of the original wood consisted of colourless, odourless plates melting at 62°C. It formed a well defined, crystalline picrate of melting point 150°C. and responded positively to tests for unsaturation. In solution in organic solvents the substance was photosensitive and gave a yellow-coloured end-product. Treatment with hydrobromic acid or preferably with dry hydrogen chloride in chloroform solution brought about almost quantitative isomerization, presumably by ring closure. The isomer is a colourless crystalline substance of melting point 258°C. The composition of the original substance was C 79·68 per cent; H 6·63 per cent; O 13·69 per cent, by difference (average of 14 analyses). The most probable molecular formula was therefore taken to be $C_{16}H_{16}O_2$, which requires C 79·97 per cent; H 6·69 per cent.

Whilst investigation of this substance was in progress in co-operation with Dr. D. H. R. Barton, of Imperial College of Science and Technology, and before its identity was established, it became known that the chemistry of the minor components of peroba de campos wood was under investigation by Professor E. R. H. Jones in the Chemistry Department of the University of Manchester. Professor Jones[1] had already recognized a crystalline component as lapachonone, and this proved to be identical with the substance isolated at the Forest Products Research Laboratory.

Lapachonone was first isolated from lapacho wood (also of the Bignoniaceae) and described in 1895[2]. This early work was confirmed by Matthes and Schreiber in 1914[3], who also found lapachol and lapachonone in a wood which

[1] Private communication.

[2] Crosa, F., and Manuelli, C. Sul lapachonone. Nouvo sostanza estratia dal legno di lapacho. *C. R. Accad. Lincei*, 1895, **4**, 250.

[3] Matthes, H., and Schreiber, E. Über hautreizende Hölzer. *Ber. dtsch. pharm. Ges.*, 1914, **24**, 385-444.

they termed "Moah-Holz" or "Edelteak-Holz". Considerable confusion has since existed about the botanical identity of this so-called Moah-Holz. In the first instance Matthes and Schreiber believed it to be a member of the Sapotaceae, but pointed out that *Flindersia australis* is sometimes known as Moah-Holz. *F. australis* is a member of the Rutaceae and contains neither lapachol nor lapachonone: neither does it contain an irritant. According to Matthes and Schreiber neither lapachol nor lapachonone is a skin irritant. The irritant principle in their Moah-Holz was an unidentified resin. The isolation of lapachonone by Matthes and Schreiber was confirmed in 1916 by Oesterle[1].

Record[2] was the first to suggest, after examination of a specimen of Moah-Holz or Edelteak-Holz submitted by Professor Matthes, that the wood belonged to the ipé peroba group of the Bignoniaceae and it was named *Tecoma peroba* (Record). Record classified the lapacho group of this family as *Tabebuia* spp. and the ipé peroba group as *Tecoma* spp.

In 1931, Kuhlmann[3] discovered what he took to be a new genus of the Bignoniaceae. He termed it *Paratecoma diandra*, but later found it to be identical with *Tecoma peroba* (Record). The name was therefore changed and the tree is now known as *Paratecoma peroba* (Record) Kuhlmann. It is of interest to have confirmed the early observations on lapachonone and to have isolated it from material of authenticated botanical identity. The constitution of the substance is at present unknown.

Chemical Enquiries

The subject matter of these enquiries was very varied and some involved a considerable amount of experimental and analytical work. In view of the shortage of well known woods imported from dollar areas, the year was marked by an increase in the number of requests for information about possible woods from sterling areas for the construction of vats and of various other items of plant and accessories used in the chemical industry. Over 40 enquiries were concerned with the diagnosis and treatment of defects such as stains, odours and gum exudations.

Many enquirers sought information on the use of wood fibre and of waste wood for the manufacture of various forms of fibreboard and, in several instances, advice was sought on the cause and prevention of metallic corrosion in wood/metal assemblies such as occur, for example, in roof construction, in aircraft, boats, automobile bodies and pianos.

ENTOMOLOGY

Insect Attack in Tropical Hardwoods

The prevalence of pinholes caused by beetles of the families Platypodidae and Scolytidae in many secondary species of hardwoods now reaching this country from the tropics has stimulated interest by both supplier and consumer in the prevention or reduction of this type of defect, so often confused with the more important damage caused by powder-post beetles in seasoned stock

[1] Oesterle, O. A. *Arch. Pharm., Berl.*, 1916, **254**, 346.
[2] Record, S. J. *Timbers of Tropical America* (p. 538). Yale University Press, New Haven, 1924.
[3] Kuhlmann, J. G. Um novo genera de Bignoniaceae. *Serv. flor. Brasil, Bol.* No. 4, 1931, 66.

and manufactured goods. At present there is a tendency for consumers to discard at sight timber showing any trace of 'worm', whether active or dead. The Laboratory has frequently been approached for advice when the suitability of 'wormy' grades of timber for structural or manufacturing purposes has been in question. In this connexion, at the request of the British Door Association, Ltd., a note was prepared for publication in the trade press on the different types of insect attack sometimes found in plywood.

As in recent years, information has again been sought by firms importing timber from the tropics—East and West Africa, Burma, Siam, Malaya, Borneo—upon methods of preventing infestation by pinhole borers in recently felled logs, pending conversion and drying. It was noted in last year's Report that a programme of research, drawn up in collaboration with the Forest Departments, has been in operation during the past three years in the Gold Coast, Malaya and British Honduras, to investigate the value of some of the newer insecticides, applied by brush or spray to logs immediately after felling, as a means of preventing infestation. The Laboratory has kept in close touch with the progress of this work and has been in a position to pass on helpful advice and information to timber importers on how to reduce risk of infestation in the country of origin. First results from Malaya have been published[1], and the Laboratory has discussed with Mr. G. H. Thompson the results of his investigations in the Gold Coast. It has been shown in both countries that best results have been obtained with Gammexane water-dispersible dust P.520, made up at the rate of 12-24 oz. per gallon of water, which is equivalent to a concentration of 0·5-1·0 per cent of the gamma isomer of benzene hexachloride. The deposit of insecticide obtained by brush or spray application is, however, liable to be washed off logs by heavy rainfall and is, therefore, effective for a much longer period if applied in the dry season. Under such conditions, protection in the Gold Coast was given for periods up to 3 months. Oil solutions of Gammexane at concentrations of 1 and 2 per cent were less satisfactory and more expensive. Formulations of D.D.T. were found not to be so effective and have not been recommended for use in practice.

Records have been maintained of the occurrence of insects, including powder-post beetles and longhorn beetles, in tropical hardwoods coming into this country, and in the course of general investigations at the Laboratory on their properties, the degree of susceptibility to infestation by *Lyctus* powder-post beetles has been assessed by examination of their starch content. Collections of insects taken from imported timbers have been identified by the Commonwealth Institute of Entomology, and the Laboratory's collection of larvae of longhorn beetles has been made available to the British Museum (Natural History) in connexion with the preparation of a publication on longhorn beetles found in imported timber.

Investigations on Lyctus *Powder-post Beetles*

In the Report for 1948 a review was given of the work carried out at Princes Risborough over a period of years on the biology and control of these common pests of the sapwood of most hardwoods during seasoning, storage and after manufacture. During the past year, further attention has been devoted to the use of D.D.T. and Gammexane for the protection of sawn timber from infes-

[1] Browne, F. G. Tests of Preservatives against Ambrosia Beetles in Malaya. *Malay. Forester*, 1949, 12 (4), 174-189.

tation. It has again been shown that a thorough spray treatment of D.D.T., applied in early spring, at a concentration of 2 per cent made up from a miscible oil in water, will prevent attack at least throughout spring and summer, and although full results are not yet available, indications have been obtained that a concentration of 1 per cent is equally effective, but that at a concentration of 0·5 per cent attack is not prevented completely. It is of interest that some residual effect, preventing normal attack by *Lyctus brunneus*, was still apparent in oak sapwood three years after spraying with a 2 per cent solution of D.D.T. in paraffin or of a 1 per cent solution of Gammexane and subsequent storing out of doors. Gammexane water-dispersible dust P.520, applied as a spray at a concentration of 2 per cent gamma isomer, gave a high degree of protection but did not entirely prevent infestation throughout one complete emergence period (March to September).

Results have been obtained during the year from the experiment described in the last Report, when two commercial size stacks of English oak on the premises of a London timber merchant were treated with a 5 per cent water emulsion of D.D.T. made up from miscible oil, and applied as a fine mist or fog. In August, 1949, some 15 months after treatment, detailed examination of test boards taken from the two piles stored in the open and under cover, respectively, showed extensive attack by *Lyctus* powder-post beetles which had developed naturally on the storage premises. In extension of this investigation and pending its results, a further experiment was started during the year when two piles of English oak (T. and T. boards), kindly supplied through Timber Control, were erected in the open at Princes Risborough. Prepared test samples were incorporated in the piles which were subjected to a fog, using a 5 per cent D.D.T. emulsion made up from a miscible oil in water for one pile, and for the other a 1 per cent suspension of Gammexane made up from the water-dispersible dust P.520. Ten weeks after treatment, some of the experimental boards and test samples were removed from treated piles and, together with untreated controls, exposed to infestation by *Lyctus* powder-post beetles. The complete results have not yet been obtained, but it is significant that beetles kept for 24 hours in contact with surfaces exposed to treatment were apparently unaffected and, when placed on untreated oak sapwood, laid eggs from which larvae developed normally. The experiment is being continued and full results are not expected before the end of summer 1950. In the meantime it appears that, applied in such a way and at such concentrations neither D.D.T. nor Gammexane is deposited on the surface of timber within such piles in adequate amounts to prevent infestation by *Lyctus brunneus*.

Kiln Sterilization against Lyctus

Heat sterilization of infested timber in a kiln is still the only reliable means of destroying on a commercial scale all stages of *Lyctus* in a single treatment. A few reports of failure have been received, but in no instance have the schedules of temperature, humidity and duration of treatment, as recommended in the Laboratory's leaflet[1] been proved to be at fault. Sometimes increased activity by the insects in the early stages of the treatment, giving rise to little heaps of bore dust which remain on the surface of the timber, has been the cause of the apparent presence of living insects. On the other hand, it is possible for failures to occur where the prescribed conditions for sterilization are not fully attained;

[1] The Kiln Sterilization of *Lyctus*-infested Timber. *Leafl. For. Prod. Res.* No. 13.

when, for instance, the air circulation is poor and, in the absence of records of temperature and humidity, faulty conditions pass undetected. This is the most likely explanation of some of the instances of failure which have been reported but not fully substantiated.

Spraying Treatment against Lyctus

Although requests for information on D.D.T. spray treatments for the prevention of *Lyctus* attack in new or sterilized stocks of hardwoods have again been received from individual firms of timber merchants and manufacturers, no developments during the year in *Lyctus* control on a wide scale can be recorded. With the ending of the control of hardwoods, the opportunity envisaged during the year of an organized attempt to protect national stocks of susceptible hardwoods by spray treatments in the spring of 1950, before *Lyctus* beetles are again in flight, appears to have been lost. The application of spray treatments and other methods of control has once again become the responsibility of the individual firm.

Enquiries on Lyctus

The enquiries received during the year on *Lyctus* and other powder-post beetles concerned infestation of sapwood in rough-sawn timber, new furniture and flooring, all of oak, chiefly English. One instance of unusual interest was the presence of widespread and severe damage to tile battens of oak and elm sapwood (Plate 8) used in 1942 for the repair of bombed property in a London district. The extent of the damage did not become apparent until late in 1948 when the roofs of the affected bungalows showed signs of sagging and had to be removed for replacement of the disintegrated battens with softwoods, which are immune from attack.

The Common Furniture Beetle, Anobium punctatum

The research, re-started in May, 1948, on the biology of this widespread household timber pest has been continued throughout the year and useful progress can be recorded. The work has, however, been severely handicapped by infestation of experimental material by the predaceous mite, *Pediculoides ventricosus.* In view of the extensive unnatural superficial boring by young larvae obtained with the muslin-covering technique described in the last Report, and of the possibility that the starch paste used as an adhesive may provide an additional nutritive substance for the larvae before entering the wood, attention has been given to other means of facilitating egg-laying. Two methods were tested—one the use of a non-nutritive adhesive for muslin and the other roughening the surfaces of the experimental blocks with a coarse wood rasp. A study of the habits of the beetles after emergence has also been undertaken to determine whether they re-enter the wood and to what extent the sexes differ in this respect. Further data have been obtained upon the incubation period of the eggs out-of-doors and under incubator conditions, and it was found that on an average the duration of the egg stage under natural conditions in the open varies from 4-6 weeks according to temperature (weather) conditions. In an incubator at 22°C. and 78 per cent relative humidity, this period was of the order of 2 weeks. The egg-laying potential of the beetles has been examined from dissections and material prepared for sectioning in connexion with histological studies.

A start has been made on examination of some of the material in the experiments upon the effect of decay in timber in relation to its suitability for attack, and also upon the comparative susceptibility of plywood made up with different types of adhesive. Insufficient material has yet been studied to allow of any definite conclusions, but it is already evident that the larvae are able to penetrate and become established in decayed wood much more easily than in sound timber. There are also indications that the rate of growth is quicker in the more severely decayed wood (40 per cent loss of weight through fungal decay) than in less severely decayed material (10 per cent loss in weight and less). These results fall into line with those obtained in past work on the closely-related deathwatch beetle, *Xestobium rufovillosum*. Furthermore, it has been noted that larvae failing to enter the wood and feeding superficially beneath a muslin covering used to facilitate-egg-laying grow more slowly than those which have penetrated. In extension of this work, a further series of samples, decayed to a known loss in weight, and additional material of old and new wood have been exposed to attack during the year both out of doors and also under controlled conditions of temperature and humidity. From the records of infestation by the common furniture beetle in this country it would appear that new timber is unsuitable for attack, but experimental proof of this is at present lacking. The experiments now in progress have been planned to investigate this important matter and, at the same time, to throw light on the nutritional requirements of the larvae.

Progress in the investigations on the susceptibility of plywood made up with different types of adhesive has been unsatisfactory. Counts of numbers of eggs laid on the experimental blocks indicate, however, that the beetles may exercise a preference for egg-laying on certain materials. Nearly twice as many eggs were laid on plywood blocks made up with blood or animal glue as on those with synthetic resins as adhesives. The mortality of larvae emerging from the eggs has been very high, and no information has as yet been obtained upon their rate of development in the different types of plywood. The work is being continued with further samples made up from Scots pine and beech with blood, hide and urea-formaldehyde glues.

Until more complete knowledge is available of the conditions which make wood suitable for attack, the rate of development of larvae and the duration of life-cycle, the common furniture beetle cannot satisfactorily be used for the development of a reliable standard insecticide test. It is for this reason that no work on these lines has been undertaken during the year, but there already exists much information on methods of control, which has been made available in the course of the Laboratory's advisory service. One-third of the total enquiries concern damage by this insect in structural woodwork, joinery and furniture. Although most of these come from private householders and builders responsible for repairs, a number was received from local authorities called upon to deal with widespread infestation in their property, attention often being focused on the problem of spread of attack to or from tenants' furniture.

Prevention of Insect Attack in Plywood

The experiments started in 1948 to determine the effect of the addition to the adhesive of 1 per cent D.D.T. or 1 per cent Gammexane upon the susceptibility of plywood to insect attack were concluded during the year, and a report for publication is in preparation. It was explained in the Report for 1948

that, owing to the lack of complete information on the biology of the common furniture beetle, it was necessary for this work to use *Lyctus brunneus* and three- and five-ply laminated samples made up from one-sixteenth and one-eighth-inch veneers of sapwood of English oak, suitable for infestation by this insect. Such material, prepared with treated and untreated animal glues, was exposed to infestation after storage under laboratory conditions of temperature and humidity for periods of 3 and 17 months. Examination subsequently showed that, irrespective of the period of storage, the inclusion of 1 per cent Gammexane in the glue line did not prevent egg-laying or hatching, but that the larvae died soon after emergence without boring in the timber. Infestation was not prevented in any of the samples by the presence of 1 per cent D.D.T., but was less extensive than in untreated controls.

These results show that the inclusion of 1 per cent Gammexane in an animal glue will prevent attack by *Lyctus brunneus* after storage periods of up to at least 17 months, but the further duration of this toxic effect has not been determined. The work is of interest in relation to similar investigations[1] with *Lyctus* beetles, now in progress at the Division of Forest Products, Melbourne, Australia, and indicates a method of preventing infestation of plywood by an insect which may attack it soon after manufacture. It is not, however, possible to say from these results to what extent this method of treatment of plywood at the time of manufacture would be effective for preventing attack by the common furniture beetle—the insect chiefly concerned in this country—which does not normally infest wood until it has been in use for a period of years.

The House Longhorn Beetle, Hylotrupes bajulus

Though the Laboratory has not been actively engaged in any experimental work with this insect, a great deal of time has been spent on problems arising out of the widespread infestation now known to occur in Surrey. Close contact has been maintained with the local authority in connexion with a survey of property carried out by the Chief Sanitary Inspector, and with the Ministry of Health in relation to the occurrence of this insect as a pest in other parts of the country. Further instances of damage have been found in other districts, and new areas in which isolated records of infestation have been noted during the year include some London suburbs, and a single case on the south coast. It has become increasingly evident that a survey should be undertaken, in these areas in the first instance, to ascertain the true extent of infestation. In the meantime, a discovery of major importance is the occurrence of the insect in a trunk of a small dead pine tree in the affected area. The possibility therefore arises that this beetle may be established under natural conditions in this country in some pine areas, and it is desirable that further survey work be undertaken to determine to what extent this obtains and how it is related to infestation of softwood structural timbers. At the same time, in view of the serious infestation recently detected in Surrey and in a few other places in the south of England, biological investigations are required on the rate of development of the insect and on the conditions favouring attack in buildings in this country, if the status of this important household timber pest is to be assessed accurately. Staff has not been available to enable the Laboratory to make a start with this work, but it has assisted in the detection of infestation,

[1] *22nd Ann. Rep. Coun. sci. industr. Res., Aust.*, 1948 (p. 56).

and has passed on to all concerned information available on methods of control used in other countries where this insect is an important pest. In this connexion, treatments were discussed with Mr. Hans Wichmand of the Danish State Entomological Laboratory, Copenhagen, when he visited Princes Risborough in July, 1949.

The Death-watch Beetle, Xestobium rufovillosum

Investigations on this insect during the year have been confined to advisory work, including 29 inspections of buildings, most of these being parish churches. Amongst the most interesting of the other buildings inspected were Buckland Abbey, Plymouth; Bisham Abbey, Marlow; the Old Ashmolean Museum, Oxford; and Sheffield Cathedral. Few instances of very extensive damage were noted, but in one Berkshire church the roof timbers of the nave were so severely affected that, following the Laboratory's report, the authorities closed the nave, pending repairs. The annual inspection of H.M.S. *Victory* was undertaken by arrangement with the Admiral Superintendent, Portsmouth Dockyard, and although active infestation by the insect still continues, the number of beetles coming out of infested wood during the emergence period in spring, 1949, showed a spectacular fall. This suggests that the control measures which have been in progress for a period of years are beginning to take effect. No final conclusions can yet be drawn so that the treatment and collection of insects annually are being continued.

Termites

The preparation of a simple manual for the practical builder, dealing with the protection of buildings and building materials from termites, has been noted earlier in this Report (p. 7).

In connexion with arrangements made with the Division of Economic Entomology, Commonwealth Scientific and Industrial Research Organization, Canberra, samples of six timber species of interest in this country have been submitted to the standard laboratory test in Australia to determine their powers of resistance to termite attack.

Control of the Predaceous Mite, Pediculoides ventricosus

Severe infestation of insect cultures and experimental material by the predaceous mite, *Pediculoides ventricosus*, which, in spite of preventive measures, has given trouble from time to time in the past, made it necessary to undertake a special investigation to develop improved methods of dealing with this laboratory pest. A series of tests was carried out to compare the toxicity, both as fumigants and as contact poisons, of beta-naphthol, benzyl benzoate, butyl phthalate and methyl benzoate, made up at a concentration of 2 per cent in 97 per cent alcohol, and of undiluted methyl benzoate upon the mite in different stages of development, and upon *Lyctus* and common furniture beetles and their larvae.

Although none of these substances killed the mature females, young mites were destroyed almost immediately on coming into contact with surfaces treated with beta-naphthol and benzyl benzoate. Exposed to a fumigant effect only, they succumbed within 24 hours. No harmful effect was noted on the wood-boring larvae and beetles. At 24°C. and 75 per cent relative humidity, conditions under which *Lyctus* cultures and most other experimental material are

maintained in incubators, this toxic effect lasted one month. Methyl benzoate was effective only when mites were in contact with surfaces treated with the undiluted liquid; butyl phthalate was ineffective.

On the basis of these results, all culture and other vessels used in experimental work, together with muslin covers and filter papers placed in the bottom of the containers, are dipped in a 2 per cent solution of beta-naphthol in 97 per cent alcohol and allowed to dry thoroughly before wood-boring insects or samples of timber are introduced. The treatment is repeated every month.

Further information is being sought on the effect of fumigation of beetles with beta-naphthol as a means of preventing infestation of cultures by the introduction of mites under the wing covers.

F. Y. HENDERSON,
Director

FOREST PRODUCTS RESEARCH LABORATORY,
Princes Risborough,
Aylesbury, Bucks.

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A. Stationery Office Publications

The Swelling of Wood under Stress. By W. W. Barkas, D.Sc.

Bulletins:

No. 22. Identification of Softwoods by their Microscopic Structure. By E. W. J. Phillips, Ph.D., B.Sc., A.R.C.S.

No. 23. Flooring Softwoods. Their Wear and Anatomical Structure. By F. H. Armstrong, M.Sc., A.M.I.Mech.E.

Records:

No. 30. The Natural Durability of Timber. By D. N. Smith.

(*For prices see page iii of cover*)

B. Other Publications

*Leaflets:**

Supplement to No. 42. Kiln-drying Schedules.

No. 44. The Seasoning Properties of Exotic Timbers—Part I.

No. 45. The Steam Bending Properties of Various Timbers—Part I.

Papers published in the Scientific and Technical Press.

Findlay, W. P. K. Recent Research in Timber Technology in Great Britain. *Brit. Sci. News*, 1949, **2** (24), 363-367.

Prevention of Decay in Newly Felled Timber. (Paper read at the Newcastle Meeting of the British Association for the Advancement of Science, Sept., 1949).

Fisher, R. C. The House Longhorn Beetle. *Timb. Plywood*, 1949, **96**(2480), 138; *Timb. News*, 1949, **57**(2116), 50; *Ill. Carp. Build.*, 1949, **138**(3727), 130; *Mun. Engng San. Rec.*, **1949,** 77; and others.

Developments in *Lyctus* Control in Great Britain. *Timb. Plywood* (Annual), **1948-1949,** 3 pp.

Household Timber Insects: Recognition, Prevention and Control of Infestation. *Sanitarian*, Nov. 1949, 25 pp.

Harris, P. Sawmilling Research. (Paper read at the Newcastle Meeting of the British Association for the Advancement of Science, Sept., 1949).

Henderson, F. Y. Anti-*Lyctus* Treatment. *Timb. Tr. J.*, 1949, **189**(3792), 917.

Lyctus-time. *Timb. Plywood*, 1949, **96**(2496), 708.

The Work of the Forest Products Research Laboratory, Princes Risborough, for the African Colonies. (Paper prepared for the *African Regional Scientific Conference*, Johannesburg, 1949, 4 pp.).

Hodge, R. E. Kiln-seasoning of Pear Wood. *Timb. Tr. J.*, 1949, **189**(3793), 1056.

Knight, R. A. G. The Doctor Roll Glue Spreader. *Wood*, 1949, **14**(1), 14-16.

Lacey, P. M. C., and Howe, H. A. Electrically-heated Cauls for Veneering. *Wood*, 1949 **14**(9), 269-274.

Pratt, G. H., and Dean, A. R. Radio Frequency Drying of Timber. *Wood*, 1949, **14**(2), 46-50.

Richardson, N. A. Wood Preservation in Great Britain. (Paper prepared for U.N. Economic and Social Council. U.N. Sci. Conf. on the Conservation and Utilization of Resources, Lake Success, 1949).

Stevens, W. C. The effect of Piling on the Distortion of Timber. *Timb. News*, 1949, **57**(2118), 145, 151.

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